NEW FABRIC DEVELOPMENT PROGRAM

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This report details an evaluation of potential candidate replacement fabrics for the Navy's 100% texturized polyester Certified Navy Twill (CNT) fabric for use in all L-1 and E-1 summer dress white uniforms and in E-1 dinner dress white and summer khaki uniforms. The Navy Clothing & Textile Research Facility (NCTRF) was directed by the Naval Military Personnel Command (NMPC) to conduct this study.

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EXECUTIVE SUMMARY

The Navy Clothing and Textile Research Facility (NCTRF) was directed by the Naval Military Personnel Command (NMPC) to conduct an evaluation of potential candidate replacement fabrics for the Navy's 100 percent texturized polyester Certified Navy Twill (CNT) fabric for application in all L-1 and E-1 summer dress white uniforms and in E-1 dinner dress white and summer khaki uniforms.

The evaluation included:

a. The selection of commercially available fabrics having the following characteristics:

   (1) White Uniform Applications

      (a) 65/35 polyester/cotton fabrics in two weights (7.6 and 8.5 oz/yd^2) finished with soil release and either pre-cured or post-cured durable press resin finishes

      (b) 65/35 polyester/rayon fabrics in two weights (7.3 and 8.8 oz/yd^2) finished with soil release and either pre-cured or post-cured durable press resin finishes

   (2) Khaki Uniform Applications

      (a) 65/35 polyester/cotton fabrics identical to those used in the white uniform applications

      (b) 6.6 oz/yd^2, 75/25 polyester/wool fabric with no special finishes.

b. The utilization of silicone resin creases in summer khaki trousers to compare the sharpness of this crease formation technique to those obtained from post-cured resin finishes and heat setting.

c. Laboratory tests to determine material physical characteristics; and appearance, soil release and dimensional stability properties after multiple launderings and dry cleanings.

d. Laboratory tests of representative uniforms manufactured from the selected fabrics to determine their appearance and dimensional stability properties after multiple launderings and dry cleanings.

e. User evaluation of summer khaki and jumper uniforms in selected candidate fabrics at three test sites selected by NMPC.

Results of these evaluations indicated:

a. White Uniform Applications

(1) Under laboratory test conditions the lighter weight polyester/cotton and polyester/rayon fabrics performed similarly when characteristics such as strength, air permeability, dimensional stability, and discoloration are grouped, and performed slightly better than their heavier weight counterparts. The prime difference between the lighter and heavier weight fabrics was the higher air permeability of the lighter weight fabrics. In rating CNT with respect to these same characteristics, its performance was considered somewhat better than the lighter weight polyester/cotton and polyester/rayon candidates because of its higher air permeability and better dimensional stability.

(2) User evaluation of the polyester/cotton fabrics in the jumper configuration indicated poor acceptance of these fabrics with respect to comfort, comparison to CNT and individual preference. Less than 10 percent of the total responses indicated the participants were cool in these uniforms, only 30 percent of the total responses indicated personnel felt these uniforms were equal to or better than CNT, and less than 50 percent of the total responses indicated that personnel had a preference for these uniforms.

(3) Because of the similarity in laboratory performance between the polyester/cotton and polyester/rayon fabrics, it was inferred that acceptability of the polyester/rayon fabrics by Naval personnel would be similar to the poor results obtained for the polyester/cotton fabrics.

b. Khaki Uniform Applications

(1) Under laboratory test conditions, the polyester/wool candidate performed somewhat better than the polyester/cotton candidates when the combined results for characteristics such as strength, air permeability, dimensional stability, soil release, and shade change are considered. Principal differences were the higher air permeability of the polyester/wool fabric (at least 26 percent higher than the polyester/cotton candidates) and a smaller change in shade after laundering with the polyester/wool fabric.

(2) User evaluations of the candidate fabrics in the summer khaki configuration indicated the polyester/wool fabric was more acceptable than the polyester/cotton fabrics with respect to comfort and individual preference. Responses indicated that 71 percent felt cool in the polyester/wool uniforms versus 25 percent or less for the polyester/cotton uniforms, and 81 percent of the responses indicated the polyester/wool uniforms were preferred versus 27 percent or less for the polyester/cotton uniforms.

(3) Additional user comments regarding comparison with CNT and cost acceptability showed that only 35 percent of the responses judged the polyester/wool fabric as equal to or better than CNT, and only 6 percent of the responses indicated that personnel would pay the $58.00 cost for the polyester/wool uniform.

c. Silicone Crease

Laboratory and user evaluations indicated that the use of silicone resin in the formation of creases would improve the sharpness and durability of the creases with respect to current methods for forming creases (post-curing of durable press finished fabrics and heat setting).

Conclusions

a. None of the candidate fabrics performed as well as CNT, particularly when user comparison responses are considered. Comfort and appearance being principal reasons. The candidate fabrics except for the polyester/wool fabric, were heavier and less air permeable than CNT, and wrinkling occurred after short periods of wear. Although the polyester/wool, candidate was considered comfortable and was preferred with respect to the other candidates, there is some question regarding its viability because of the high cost of this uniform compared to uniforms made from CNT and the other candidate materials.

b. To achieve greater acceptability for a cost effective replacement fabric for CNT, a polyester/cotton fabric having the same durable press and soil release resin finishes used in this study, that is lighter and more air permeable than the candidate fabrics studied and mimics CNT with respect to these properties appears to be the best choice. Employing a silicone resin in the formation of creases in uniforms made from this fabric should provide a uniform as comfortable as CNT and approach CNT in appearance to the extent possible with this type of fabric.

c. The 6.5 oz/yd^2, 65/35 polyester/cotton fabric used in the trousers of the E-1 summer white uniforms has similar weight and air permeability properties as CNT and would appear to be the logical fabric replacement choice for CNT when finished with durable press and soil release resins based on the results of this evaluation.

Recommendation

It appears that the most reasonable option for a CNT replacement fabric would be a polyester/cotton fabric having the same weight and air permeability characteristics as the CNT fabric, finished with a durable press and soil release resins to maximize appearance and soil removal properties, and the formation of silicone resin creases in garments made from this fabric to further enhance appearance.

Comfort properties should improve from what was achieved in this study with heavier polyester/cotton fabrics and appearance should be similar to that achieved with the polyester/cotton fabrics in this study with more wrinkling during wear than would occur with CNT.

The 6.5 oz/yd^2, 65/35 polyester/cotton fabric used in E-1 summer white trousers would appear to be a suitable choice. It mimics CNT in weight and air permeability characteristics and finished with both a durable press and soil release resins, its appearance and soil removal properties would be improved.

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NEW FABRIC DEVELOPMENT PROGRAM

INTRODUCTION

At the direction of the Naval Military Personnel Command (NMPC), the Navy Clothing and Textile Research Facility (NCTRF) initiated a program in December 1985 to evaluate potential candidate replacement fabrics for the Navy's 100 percent texturized polyester certified Navy twill (CNT) fabric.

Under this program the potential candidate materials were evaluated to determine their suitability in all L-1 and E-1 summer dress white uniforms, and in E-1 dinner dress white and summer khaki uniforms.

The evaluation involved the selection of commercially available white and khaki fabrics that based on their physical and finish characteristics would potentially meet the functional requirements for a Navy dress uniform fabric.

The candidate materials selected for the white uniforms were composed of 65/35 polyester/cotton and 65/35 polyester/rayon blends in different weights and were finished with pre and post-cured durable press and soil release resin finishes. The candidate khaki uniform fabrics were polyester/cotton fabrics having the same physical properties and finishes used for the white fabrics, and a 75/25 polyester/wool fabric.

The selected fabrics were evaluated in the laboratory to determine their physical characteristics; and appearance, soil release and dimensional stability properties after multiple launderings and dry cleanings.

Representative uniforms manufactured from the selected fabrics were also laboratory evaluated to determine their appearance and dimensional stability properties after multiple launderings and dry cleanings. In addition, summer khaki and jumper uniforms constructed from some of the candidate fabrics were evaluated at three test sites selected by NMPC to determine their acceptability by Naval personnel. Summer khaki uniform trousers constructed from polyester/cotton pre-cured fabrics also contained creases formed with a silicone resin to determine the relative improvement in crease sharpness and durability offered by this approach with respect to creases obtained with either post-cured durable press resin finishes or by heat setting.

As a result of this evaluation the following was determined:

1. All polyester/cotton, polyester/rayon and polyester/wool candidate materials had suitable physical, dimensional stability, appearance and soil release properties based on laboratory evaluations. However user evaluation data indicated that the candidate fabrics with the exception of the polyester/wool fabric were unsuitable with respect to comfort, poor acceptance compared to CNT, and low preference. It appeared that the poor acceptance of the polyester/cotton and polyester/rayon fabrics was due in part to their being heavier and less air permeable than CNT. In the user trial, the polyester/wool fabric was more acceptable than the other candidates with respect to comfort and preference and more closely mimicked the CNT fabric with respect to weight and air permeability than the other candidates.

2. The viability of using the polyester/wool fabric in summer khaki uniforms appears questionable based on user evaluation data regarding comparison to CNT and cost. Only 35 percent of the responses received indicated that the polyester/wool fabric was equal to or better than CNT and only 6 percent indicated that the $58.00 cost for a polyester/wool uniform was acceptable.

3. To achieve a better degree of acceptability of polyester/cotton materials with respect to CNT a lighter and more air permeable fabric which mimics these properties of CNT is required and finished with durable press and soil release resins as were the polyester/cotton and polyester/rayon fabrics evaluated in this study to maximize appearance and soil removal properties. In addition the silicone resin evaluated for forming creases should be employed since sharp and durable creases can be achieved with this process to further enhance the appearance of the polyester/cotton uniforms.

4. The 6.5 oz/yd^2, 65/35 polyester/cotton fabric currently used in the E-1 summer white trousers would appear to be a suitable choice as a CNT replacement fabric when finished with both durable press and soil release resins since it mimics the CNT fabric in weight and air permeability.

This report includes background information relating to this investigation, descriptions of all candidate fabrics employed, the approach and procedures used to evaluate the candidate fabrics, results obtained, and the conclusions and recommendations derived from these results.

BACKGROUND

In January 1982, the CNT fabric was first introduced to Naval personnel. The fabric was eventually used in all L-1 and E-1 service dress white uniforms, and E-1 dinner dress white and summer khaki uniforms.

Shortly after the introduction of the CNT fabric there were numerous complaints from Navy personnel regarding the durability and cleanability of the fabric. There were complaints that the fabric pilled and snagged and soil spots were difficult to remove. With the completion of the development of a soil release finish for the fabric in December 1983, the complaints regarding soil removable problems diminished considerably, however pilling and snagging of the fabric continued to be a problem.

Based on these complaints the SECNAV in September 1985 directed that the CNT fabric be replaced with a suitable polyester/cotton fabric. In December 1986 the NMPC directed NCTRF to evaluate potential candidate replacement fabrics for CNT. The requirements for the replacement fabric were:

1) Could not be made from 100 percent polyester fiber
2) Good appearance
3) Able to be maintained by Naval personnel with minimum care
4) Able to be used for both top and bottom type garments to achieve a vertical match.

APPROACH

Fabrics

Commercially available fabrics in white and khaki shades having physical and finish properties potentially suitable for use in Naval uniforms currently made from the CNT fabric were selected. Table I lists the materials selected and their general characteristics. Also listed are the general characteristics of the CNT fabric.

The candidate fabrics (polyester/cotton and polyester/rayon) with the exception of the 75/25 polyester/wool khaki fabric weighed between 7 and 9 oz/yd^2 and were of right hand twill construction, having a soil release and either a pre-cured or post-cured durable press resin finish.

A pre-cured durable press resin finish is fully cross-linked during the fabric finishing process. A post-cured durable press resin finish is partially cross-linked during the fabric finishing process and is completely cross-linked after the fabric has been constructed into garment form and pressed. Creases in post-cured garments have some degree of durability after cleaning because they have been set during the post curing process.

The 75/25 polyester/wool fabric was the lightest of the candidate fabrics (6.6 oz/yd^2), had a tropical (plain) weave construction but did not have a durable press resin finish or a soil release finish. Fabrics with high concentrations of polyester fibers are given some degree of easy care properties by heat setting the thermoplastic polyester fibers in the fabric finishing process. Creases in garments can be made somewhat permanent when pressed with sufficient heat. No soil release finish was used for the polyester/wool fabric because there was no currently available suitable finish for this fabric blend at the time it was selected.

The current CNT fabric (100 percent polyester), similiar to the polyester/wool fabric obtains its easy care properties by heat setting the polyester fibers in the fabric finishing process and garment creases can be made permanent to some degree when pressed with sufficient heat. The current CNT fabric has a soil release finish, weighs approximately 6.7 oz/yd^2 and is of right hand twill construction.

Sufficient quantities of each candidate fabric were obtained to conduct laboratory physical and performance evaluations and to construct uniforms from these fabrics for both laboratory and user performance evaluations.

The laboratory evaluations of the candidate fabrics determined their physical characteristics; appearance performance after multiple launderings and drycleanings with respect to wrinkling behavior, discoloration (whites), shade change (khaki), and soil release properties; and dimensional stability characteristics after multiple launderings and dry cleanings.

Table I - General Characteristics of Candidate Replacement Materials and CNT

Blend (%)	Weight (oz/yd^2)	Construction* (Weave)	Shade	Finishes	
				Durable Press	Soil Release
65/35 Polyester/ Cotton	7.6	2 X 1 RHT	White	Pre-Cured	Yes
				Post-Cured	Yes
			Khaki	Pre-Cured	Yes
				Post-Cured	Yes
	8.5	3 X 1 RHT	White	Pre-Cured	Yes
				Post Cured	Yes
			Khaki	Pre-Cured	Yes
				Post-Cured	Yes
65/35 Polyester/ Rayon	7.3	2 X 1 RHT	White	Pre-Cured	Yes
				Post Cured	Yes
	8.8	2 X 1 RHT	White	Pre-Cured	Yes
				Post Cured	Yes
75/25 Polyester/ Wool	6.6	Tropical/ Plain	Khaki	None	None
100** Polyester	6.7	2 X 1 RHT	White	None	Yes
			Khaki	None	Yes

* RHT - Right Hand Twill
** - CNT

Table II shows the fabric codes assigned to each of the candidate fabrics. The code descriptors represent the following:

8, 7,6	- Nominal weight of fabric in oz/yd^2
PC, PR, PW	- Fabric blend - polyester/cotton, polyester/rayon, polyster/wool
K, W	- Fabric shade - khaki, white
Pr, Po	- Durable press resin finish - pre-cured, post-cured
SR	- soil release finish

Uniforms

Table III lists the types of uniforms constructed from the candidate fabrics. The pre-cured polyester/cotton candidate khaki fabric uniforms had in addition to the fabric finishes a silicone resin finish applied to the creases of the trousers, which was cured (cross-linked) during the formation of the creases to obtain a durable sharp crease appearance.

Laboratory evaluation of the uniform items determined their appearance performance after multiple launderings and dry cleanings with respect to wrinkling behavior and dimensional stability characteristics.

User evaluations were also conducted on selected candidate fabrics to determine acceptability by Naval personnel. Table IV indicates the test sites selected, the fabric combinations compared for each type of uniform evaluated and the number of uniform combinations compared.

Because of the limited nature of the user evaluation only men's uniforms were evaluated and limited to the summer khaki, and the service dress white jumper uniforms.

Only the polyester/cotton and polyester/wool candidate fabrics were tested in the summer khaki uniforms. For the service dress white jumper uniforms, selected polyester/cotton and polyester/rayon candidate fabrics were evaluated.

A total of 39 volunteers participated in the user evaluation. Ten evaluated the service dress white jumper uniforms and 29 evaluated the summer khaki uniforms.

Table II - Fabric Codes Assigned to Candidate Fabrics

Code	Description				
	Nominal Weight (oz/yd^2)	Blend	Shade	Finish	
				Durable Press	Soil Release
8-PC-K-Pr-SR	8.0	65/35 Poly/Ctn	Khaki	Pre-Cured	Yes
8-PC-W-Pr-SR			White	" "	"
8-PC-K-Po-SR			Khaki	Post-Cured	"
8-PC-W-Po-SR			White	" "	"
7-PC-K-Pr-SR	7.0	65/35 Poly/Ctn	Khaki	Pre-Cured	"
7-PC-W-Pr-SR			White	" "	"
7-PC-K-Po-SR			Khaki	Post-Cured	"
7-PC-W-Po-SR			White	" "	"
8-PR-K-Pr-SR	8.0	65/35 Poly/Ray	Khaki	Pre-Cured	"
8-PR-W-Pr-SR			White	" "	"
8-PR-K-Po-SR			Khaki	Post-Cured	"
8-PR-W-Po-SR			White	" "	"
7-PR-K-Pr-SR	7.0	65/35 Poly/Ray	Khaki	Pre-Cured	"
7-PR-W-Pr-SR			White	" "	"
7-PR-K-Po-SR			Khaki	Post-Cured	"
7-PR-W-Po-SR			White	" "	"
6-PW-K	6.6	75/25 Poly/Wool	Khaki	No	No

Table III - Types of Uniforms Evaluated

Category	Uniform Component	
	Men's	Women's
Summer Khaki [1]	Shirt, Short Sleeves Trousers	Shirt, Short Sleeves Skirt Slacks
Service Dress White	Coat Trousers Jumper Jumper Trousers	Coat Skirt
Dinner Dress White	Jacket	Jacket

[1] Pre-cured candidate khaki fabric uniform trouser creases were formed with a permanent (cross-linked) silicone resin.

Table IV - Uniform Distribution Sites and Fabric Comparison Information for User Evaluation

Evaluation

Test Site	Uniform Compared	Fabric Combinations Compared	Number of Uniform Combinations Compared
NAF Mayport	Summer Khaki, Men's	8-PC-K-Pr-SR VS. 8-PC-K-Po-SR	2
		VS. 7-PC-K-Pr-SR	4
		VS. 6-PW-K	3
		8PC-K-Po-SR VS. 7-PC-K-Po-SR	4
		VS. 6-PW-K	4
		7-PC-K-Pr-SR VS. 7-PC-K-Po-SR	2
		VS. 6-PW-K	1
		7-PC-K-Po-SR VS. 6-PW-K	3
Misc Personnel	Summer Khaki, Men's	8-PC-K-Pr-SR VS. 6-PW-K	3
		8-PC-K-Po-SR VS. 6-PW-K	1
		7-PC-K-Pr-SR VS. 6-PW-K	1
		7-PC-K-Po-SR VS. 6-PW-K	1
NAS Pensacola	Service Dress White Jumper	8-PC-W-Pr-SR VS. 8-PC-W-Po-SR	2
		VS. 7-PC-W-Pr-SR	2
		8-PC-W-Po-SR VS. 7-PC-W-Po-SR	2
		VS. 7-PR-W-Pr-SR	1
		VS. 7-PR-W-Po-SR	1
		7-PC-W-Pr-SR VS. 7-PC-W-Po-SR	1
		VS. 8-PR-W-Po-SR	1
Totals	Summer Khaki, Men's		29
	Service Dress White Jumper		10

PROCEDURE

Laboratory Evaluations

Fabrics

Tables V and VI list the test procedures employed in evaluating the candidate materials in the laboratory.

The physical characteristics of the candidate materials (weight, yarn ply, construction, texture, break and tear strength, and air permeability) were determined using visual or the specific test methods noted in Table V.

In determining the performance characteristics of the candidate materials, combinations of some of the methods listed in Table V were used for the specific laundering and dry cleaning conditions employed. Table VI reflects how these different methods were combined depending upon whether the test item was a material or a garment, or depending upon the particular characteristic being rated/measured. Except as indicated all methods employed in the performance tests conformed to the American Association of Textile Chemists and Colorists (AATCC) procedures.

Durable Press Appearance - Appearance was determined under both accelerated laundering and dry cleaning procedures with small fabric samples in a Launder-Ometer. Each laundering cycle using the accelerated method is cited as being equivalent to five commercial launderings. For the accelerated dry cleaning method this procedure is cited as being equivalent to a non-specific number of repeated commercial dry cleanings. In the laundering tests the standard AATCC detergent without optical brightener (WOB) was used and no bleach was used. In the dry cleaning tests the solvent employed was perchloroethylene. Durable press ratings were scored before and after pressing the material samples. The rating scale was as follows:

1. Crumpled, Creased, and Severely Wrinkled Appearance
2. Rumpled, Obviously Wrinkled Appearance
3. Mussed, Non-Pressed Appearance
4. Smooth Finished Appearance
5. Very Smooth, Pressed, Finished Appearance

Soil Release - The accelerated laundering and dry cleaning procedures used in the durable press appearance evaluations were also used in evaluating the soil release properties of the materials. The AATCC soil release procedure was modified to that developed by NCTRF for CNT. The modified NCTRF procedure uses a graphite-oil stain which is more difficult to remove than the "Nujol" mineral oil stain used in the AATCC procedure and the degree of stain removal is rated using a stain release replica developed by NCTRF (Appendix A).

Discoloration/Shade Change - Discoloration for the white fabric samples was determined from tristimulus reflectance data measured with a spectrophotometer which were converted to whiteness and yellowness indices and reported as a percentage change in these indices from the original samples. For the khaki samples shade change was also determined from tristimulus reflectance data converted to E values which were reported as changes in E values from the oriiginal samples. The E value represents the resultant color change of the samples due to changes in lightness, hue, and chroma.

Dimensional Stability - Shipboard laundering procedures were employed in measuring this characteristic. The standard Government detergent P-D-245-C was used with an alkali, non-ionic softener, and blue sour. No bleach was employed.

Uniforms

Table V and VI also lists the test procedures employed in evaluating uniforms constructed from the candidate fabrics. The performance properties measured on the candidate uniforms were appearance before and after pressing in the laundering tests, and appearance before pressing in the dry cleaning tests; dimensional stability; and the efficacy of silicone creases with respect to creases formed with post-cured resins. The dry cleaning evaluations were performed by the International Fabricare Institute (IFI).

Durable Press Appearance - Ratings were performed similarly to the method used for materials except upper garments were viewed on hangers and lower garments draped from clamps. Laundering and dry cleaning methods were identical to those used to determine material discoloration/shade change.

Dimensional Stability - The laundering and dry cleaning methods were identical to those used to determine material discoloration/shade change. Dimensional changes were measured for selected girth and length dimensions.

Crease Appearance - Crease appearance was measured subjectively and rated as excellent, good, fair, or poor, before and after pressing, after five laundering cycles, employing the shipboard laundering and dry cleaning procedures indicated previously.

User Evaluations

As shown in Table IV user evaluations were conducted on men's summer khaki and service dress white jumper uniforms in the fabric candidates indicated. There were 39 test participants, 29 officers and 10 enlisted who evaluated 78 uniforms, 58 summer khaki and 20 service dress white jumper uniforms. The test uniforms were worn over a period of two months during the September and October 1986 timeframe.

Briefings were held with most test participants prior to the start of the evaluation and at its conclusion. Arrangements were made with various uniform tailor shops to permit alterations of the uniforms (heming and attachment of rating badges on jumper uniforms) prior to their wear in the evaluation.

Questionnaire forms (Appendix B) were provided each participant to develop information relative to the following characteristics:

a. Initial Fit
b. Cleaning Methods Employed
c. Degree of Dimensional Change
d. Ease of Stain Removal
e. Need for Pressing after Cleaning
f. Appearance After Wear/Cleaning
g. Durability
h. Comfort
i. Comparability to CNT
j. Cost Acceptability (Khaki Unforms only)
k. Overall Preference

In addition comments were requested regarding the efficacy of the silicone creases with respect to the creases formed with post-cured resin treated fabrics.

Table V - Material/Garment Laboratory Test Methods

Characteristic	Test Method **
Weight	5041
Yarn Ply	Visual
Construction	Visual
Texture	5050
Break Strength	5100
Tear Strength	5132
Air Permeability	5450
Durable Press	AATCC-124-1978
Soil Release	AATCC-130-1977/NCTRF
Discoloration/Shade Change	AATCC-153-1978
Dimensional Stability, Materials	AATCC-96-1981
Dimensional Stability, Garments	AATCC-150-1979
Accelerated Dry Cleaning	AATCC-86-1979
Shipboard Laundering	NAVEDTRA 414-01-45-81, Formula II
Commercial Dry Cleaning	AATCC-158-1979

** Federal Standard for Textile Test Methods No. 191 A, except where noted.

Table VI - Performance Procedures for Laboratory Evaluation of Materials and Uniforms

Methods Procedure	Characteristic					
	Material				Garment	
	Appearance	Soil Release	Discolor/ Shade	Dim. Sta.	Appearance	Dim. Sta.
Rating/ Measurement	124-1978	130-1977/ NCTRF	153-1978	96-1980	124-1978	150-1979
Laundering						
Method	61-1980	61-1980	NAVEDTRA Formula II	NAVEDTRA Formula II	NAVEDTRA Formula II	NAVEDTRA Formula II
Wash Temp(^{o}F)	160	160	140	140	140	140
Drying Method	Line Dry	Line Dry	Tumble	Tumble	Tumble	Tumble
Drying Temp(^{o}F)	75	75	140-180	140-180	140-180	140-180
Press. Meth.	Flat Bed	Flat Bed	Flat Bed	Flat Bed	Flat Bed	Flat Bed
Press. Temp(^{o}F)	275-300	275-300	275-300	275-300	275-300	275-300
Number of cycles	5	5	10	5	5	5
Dry Cleaning						
Method	86-1979	86-1979	158-1979	158-1979	158-1979	158-1979
Solvent Temp(^{o}F)	80	80	86	86	86	86
Drying Method	Line Dry	Line Dry	Tumble	Tumble	Tumble	Tumble
Drying Temp(^{o}F)	75	75	140 Max	140 Max	140 Max	140 Max
Pressing Method	Flat Bed	Flat Bed	None	None	None	None
Press Temp(^{o}F)	275-300	275-300	-----	-----	-----	-----
Number of cycles	3	3	5	5	5	5

RESULTS

Laboratory/Fabrics

Physical/Dimensional Stability Characteristics

Table VII shows the physical and dimensionsl stability characteristics of the candidate materials and CNT. The properties of similar white and khaki candidate fabrics were combined.

All of the candidate materials had suitable physical properties with respect to break and tear strength and there were no significant differences in these properties for those materials that either had a pre-cured or post-cured durable press resin finish.

Air permeability results were directly related to the weight and texture of the fabrics. The heavier the fabric and the denser the yarn cross-over pattern (texture) the lower the air permeability. Values were as low as 17 $ft^3/min/ft^2$ for the 8.5 oz/yd^2 polyester/cotton fabric and as high as 36 $ft^3/min/ft^2$ for the 6.6 oz/yd^2 polyester/wool fabric.

Dimensional stability results were generally within normal specification limits for the types of fabrics evaluated. Those exceeding normal specification limits for this characteristic were the 7.6 oz/yd^2, polyester/cotton, pre-cured fabric; 7.3 oz/yd^2, polyester/rayon, pre-cured fabric, and the 6.6 oz/yd^2 polyester/wool fabric. Specification limits normally established for these types of fabrics are as follows:

Type	Dimensional Change (%)		Washing Temp. (Deg F)
	Warp	Filling	
Polyester/Cotton	2.0	2.0	140
Polyester/Rayon	3.5	2.0	100
Polyester/Wool	2.5	2.5	140
Polyester	2.0	2.0	160

With respect to the current CNT fabric the polyester/wool candidate fabric more closely mimicked the properties of the CNT than any of the other candidate fabrics. It was in the same weight and texture range and more closely approached the air permeability characteristic of CNT.

Durable Press Appearance

Figures 1, 2 and 3 show the durable press ratings for the candidate materials and CNT after five accelerated laundering and three accelerated dry cleaning cycles before and after pressing.

Table VII Physical and Dimensional Stability Characteristics of Candidate Materials and CNT

Characteristic	Fabric 1/									
	8-PC-Pr-SR	8-PC-Po-SR	7-PC-Pr-SR	7-PC-Po-SR	8-PR-Pr-SR	8-PR-Po-SR	7-PR-Pr-SR	7-PR-Po-SR	6-PW	CNT
Weight (oz/yd^2)	8.6	8.4	7.6	7.6	8.6	8.9	7.3	7.3	6.6	6.7
Yarn Ply (Warp & Filling)	Singles	Singles	Singles	Singles	2 Ply	2 Ply	2 Ply	2 Ply	2 Ply	2 Ply
Construction (Weave) 2/	3X1 RHT	3X1 RHT	2X1 RHT	2X1 RHT	2X1 RHT	2X1 RHT	2X1 RHT	2X1 RHT	Plain	2X1 RHT
Texture (Yarns/Inch)										
Warp	114	114	91	91	96	96	88	88	51	51
Filling	54	54	53	53	44	44	51	51	46	46
Break Strength (lbs.)										
Warp	287	295	251	248	276	285	230	223	180	264
Filling	106	126	127	124	113	137	130	127	164	251
Tear Strength (lbs.)										
Warp	3/ Res Tear	20	14	13	15	13	10	12	8	13
Filling	7	10	7	7	8	10	8	10	7	13
Air Permeability ($ft^3/min/ft^2$)	18	17	25	24	24	22	34	32	36	44
Dimensional Stability (5 Laund) (%)										
Warp	1	2	3	2	3	2	2	3	3	2
Filling	1	0	1	0	2	1	3	1	1	1

1/ Data for similar white and khaki fabrics combined
2/ RHT - Right hand twill
3/ Res. Tear - Straight tear could not be obtained

The polyester/cotton white samples whether pre or post-cured had a durable press rating of 4 or greater after laundering and before pressing and ratings of 5 were obtained after pressing. In the dry cleaning tests the durable press rating was 3 for all of the samples before pressing which increased to at least 4 after pressing. CNT had ratings of at least 4 after laundering or dry cleaning before pressing and 5 after pressing (Fig. 1). The polyester/rayon white samples whether pre or post-cured showed durable press ratings similar to the polyester/cotton white fabrics before and after pressing (Fig. 2).

The polyester/cotton khaki samples whether pre or post-cured showed as expected durable press ratings before and after pressing similar in most cases to their white counterparts. The polyester/wool candidate sample had ratings equivalent or better than the polyester/cotton samples (Fig. 3).

Durable press ratings after laundering and before pressing were essentially equivalent (4 rating) for all candidate white and khaki samples and CNT. Ratings after dry cleaning and before pressing were equivalent (3 rating) for all polyester/cotton and polyester/rayon samples. The polyester/wool sample had a 4 rating under this condition and CNT had a 5 rating.

Soil Release

Figures 4, 5, and 6 show the soil release ratings for the candidate materials and CNT after five accelerated laundering and three accelerated dry cleaning cycles.

All polyester/cotton, polyester/rayon and polyester/wool samples had 3 ratings after laundering., CNT had a 4 rating for this condition. For the dry cleaning condition the white 8 oz/yd^2 polyester/cotton samples and all polyester/rayon samples had a 4 rating. CNT had a 5 rating for this condition (Fig 4 and 5). For the dry cleaned khaki samples (Fig. 6) the 8 oz/yd^2 pre-cured polyester/cotton samples had the highest rating (5) and the 6 oz/yd^2 polyester/wool samples had the lowest rating (3).

Whiteness Change

Figures 7 and 8 indicate the percent change in whiteness of the polyester/cotton and polyester/rayon samples and CNT after ten shipboard laundering cycles and five commercial dry cleaning cycles.

Loss in whiteness ranged from 10 to 32 percent for the polyester/cotton samples with the post-cured fabrics showing greater loss in whiteness than the pre-cured fabrics under the laundering condition. For the dry cleaning condition only the 7 oz/yd^2 polyester/cotton post-cured sample showed appreciable loss in whiteness (28 percent). Under both the laundering and dry cleaning conditions CNT increased in whiteness (Fig 7).

Loss in whiteness for the polyester/rayon samples under the laundering condition was not as significant in general as occurred with polyester/cotton samples. Maximum loss was 13 percent for the 7 oz/yd^2 polyester/rayon post-cured sample. This same candidate also showed the

greatest reduction in whiteness for the dry cleaning condition (8 percent). The other polyester/rayon candidates showed increased whiteness under the dry cleaning condition by as much as 8 percent for the 8 oz/yd^2 candidates.

Yellowness Change

Figures 9 and 10 indicate the percent change in yellowness of the polyester/cotton and polyester/rayon samples and CNT after ten shipboard laundering and five commercial dry cleaning cycles. There was little change in yellowness for all candidate polyester/cotton and polyester/rayon samples and CNT. Maximum increase in yellowness was less than two percent for all materials.

Shade Change

Figure 11 indicates the total color change (ΔE) for the khaki candidate materials after ten shipboard laundering and five commercial dry cleaning cycles. The total color change indicated was primarily due to change in lightness.

Maximum color change occurred under the laundering condition. The polyester/cotton samples became lighter in shade and the polyester/wool material became darker in shade under this condition. Relative change in shade was greater for the polyester/cotton samples with ΔE values ranging between +1.8 and +2.5 whereas the change in ΔE for the polyester/wool samples was -1.2.

Uniforms

Durable press ratings and dimensional stability data for white and khaki uniforms, and silicone crease results after five shipboard and commercial dry cleaning cycles are shown in Tables VIII through XVI.

Durable Press Ratings

Tables VIII and IX show the durable press ratings for the white uniforms and Tables X and XI for the khaki uniforms after shipboard laundering and dry cleaning before and after pressing.

White Uniforms After Laundering (Table VIII)

For the men's uniforms the best overall performance before pressing was achieved with either the pre or post-cured 8 oz/yd^2 polyester/cotton fabrics. The other candidate fabrics including CNT performed similarly. The average durable press rating for the 8 oz/yd^2 polyester/cotton fabrics was 3 whereas the other fabrics averaged approximately 2. Based on these ratings all uniforms would require some degree of pressing.

For the women's uniforms the best overall performance before pressing was achieved with the 7 oz/yd^2 polyester/cotton post-cured fabric. The average rating was 3. For the other fabrics tested in the three women's uniforms the average rating was approximately 2. As with the men's uniforms these ratings indicate that some degree of pressing would be needed.

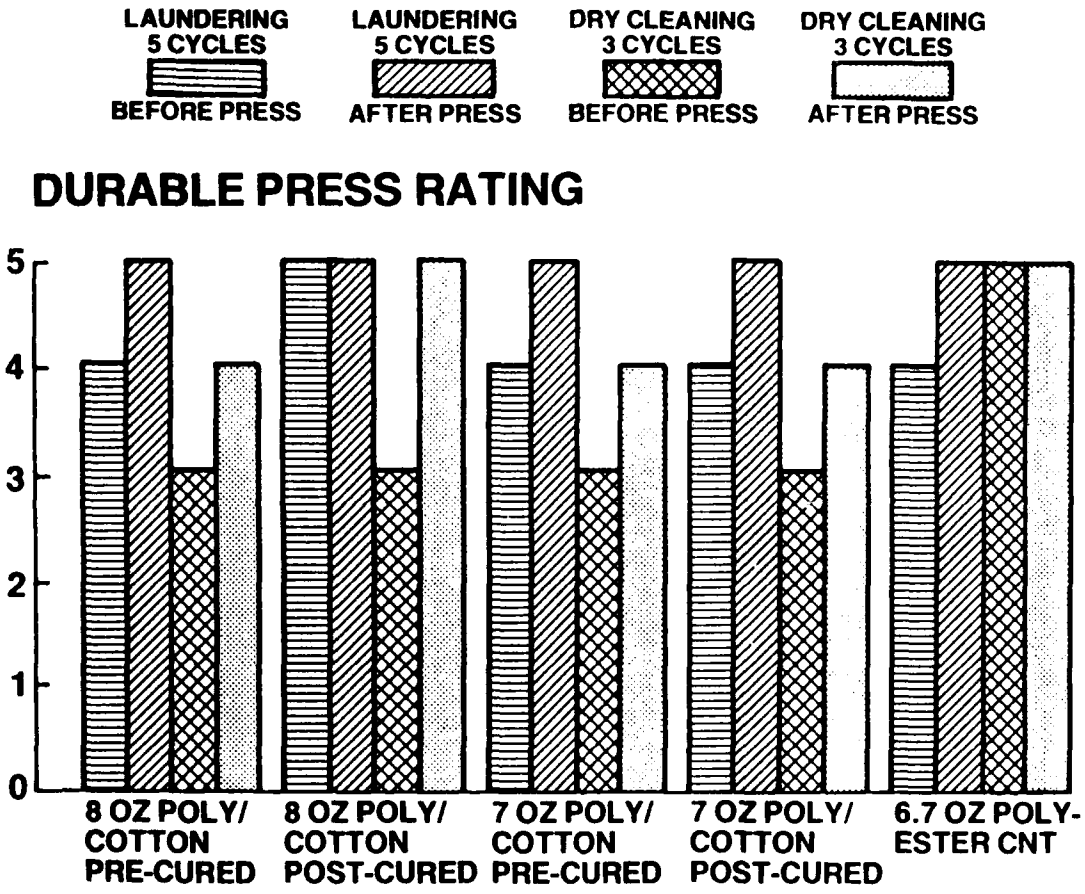

FIGURE 1: DURABLE PRESS RATINGS FOR POLYESTER COTTON WHITE FABRICS VERSUS CNT

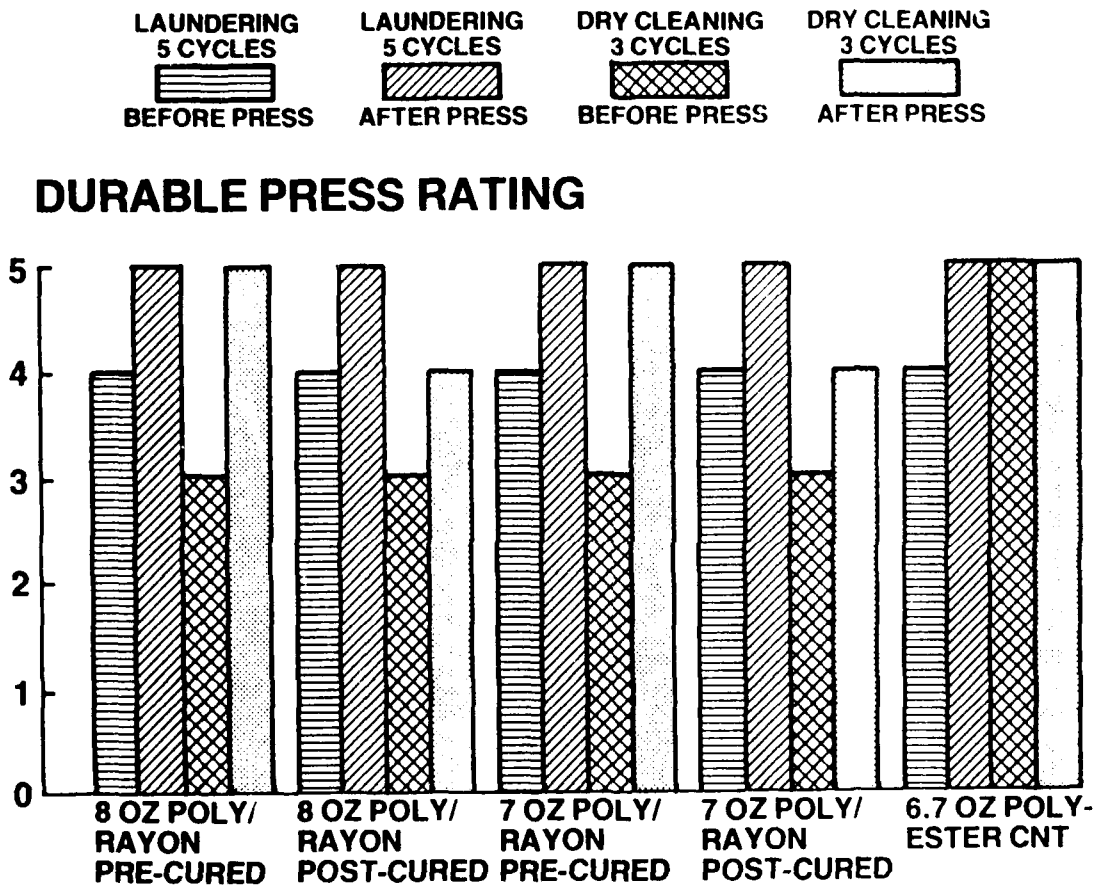

FIGURE 2: DURABLE PRESS RATINGS FOR POLYESTER/RAYON WHITE FABRICS VERSUS CNT

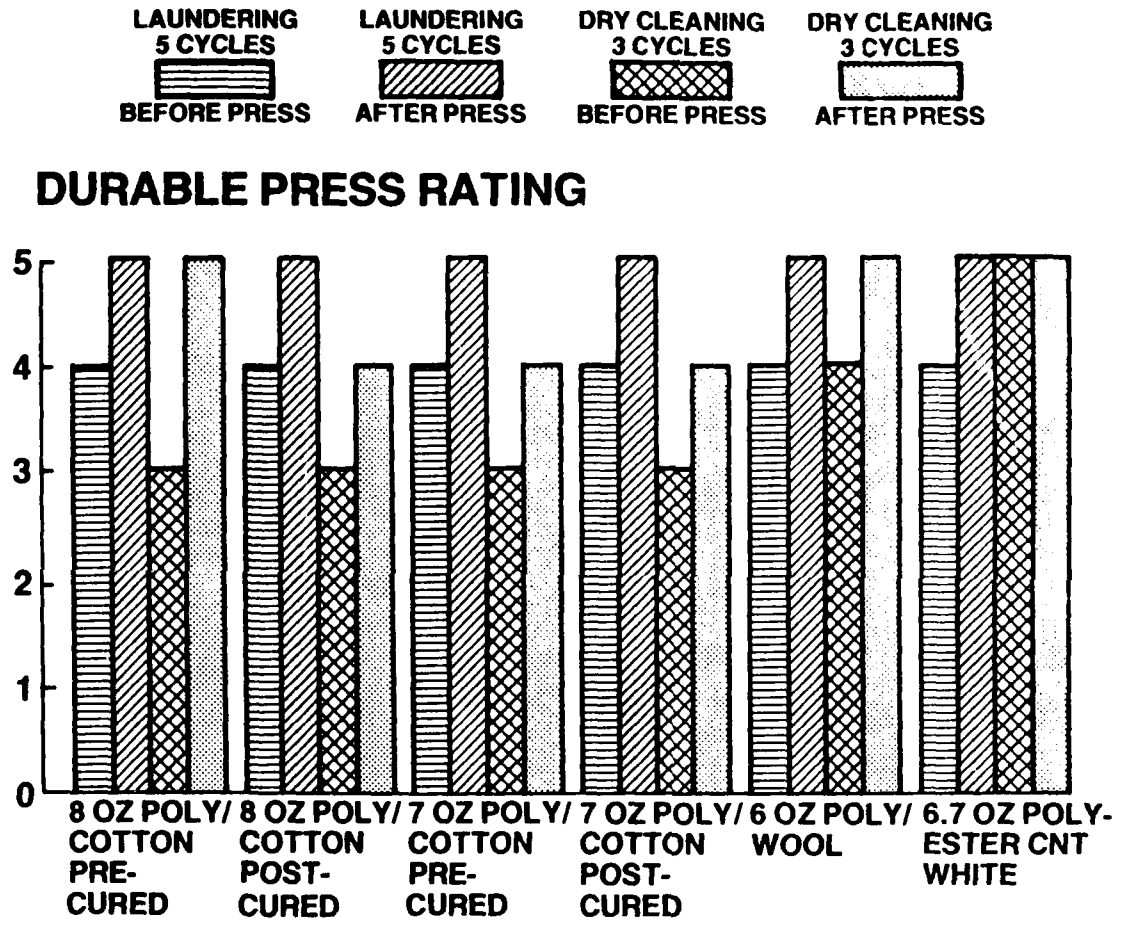

FIGURE 3: DURABLE PRESS RATINGS FOR POLY/CTN AND POLY/WOOL KHAKI FABRICS VERSUS CNT

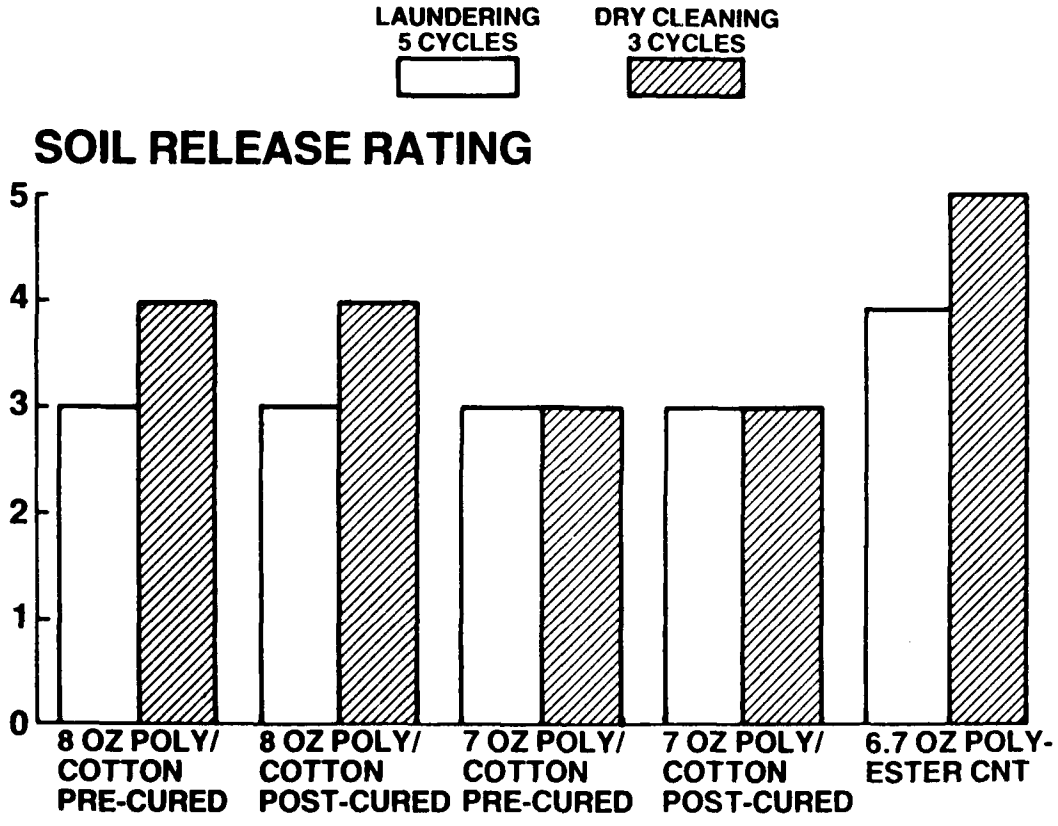

FIGURE 4: SOIL RELEASE RATINGS FOR POLYESTER/COTTON WHITE FABRICS VERSUS CNT

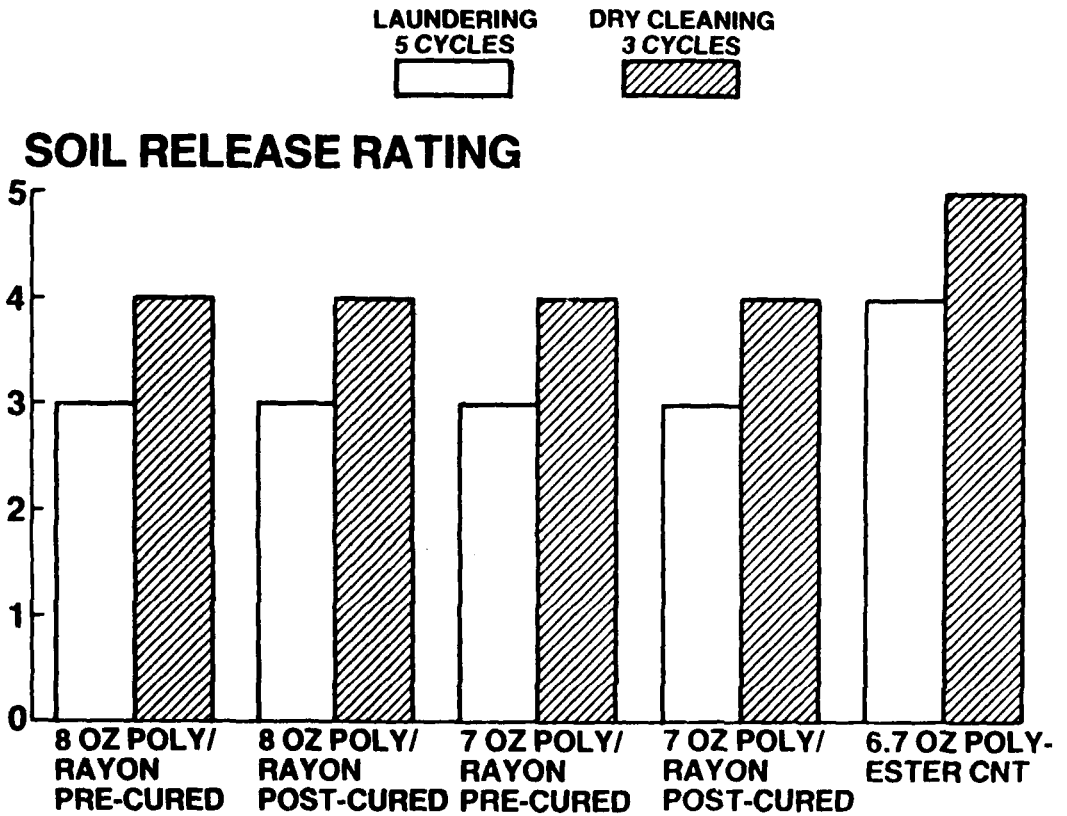

FIGURE 5: SOIL RELEASE RATINGS FOR POLYESTER/RAYON WHITE FABRICS VERSUS CNT

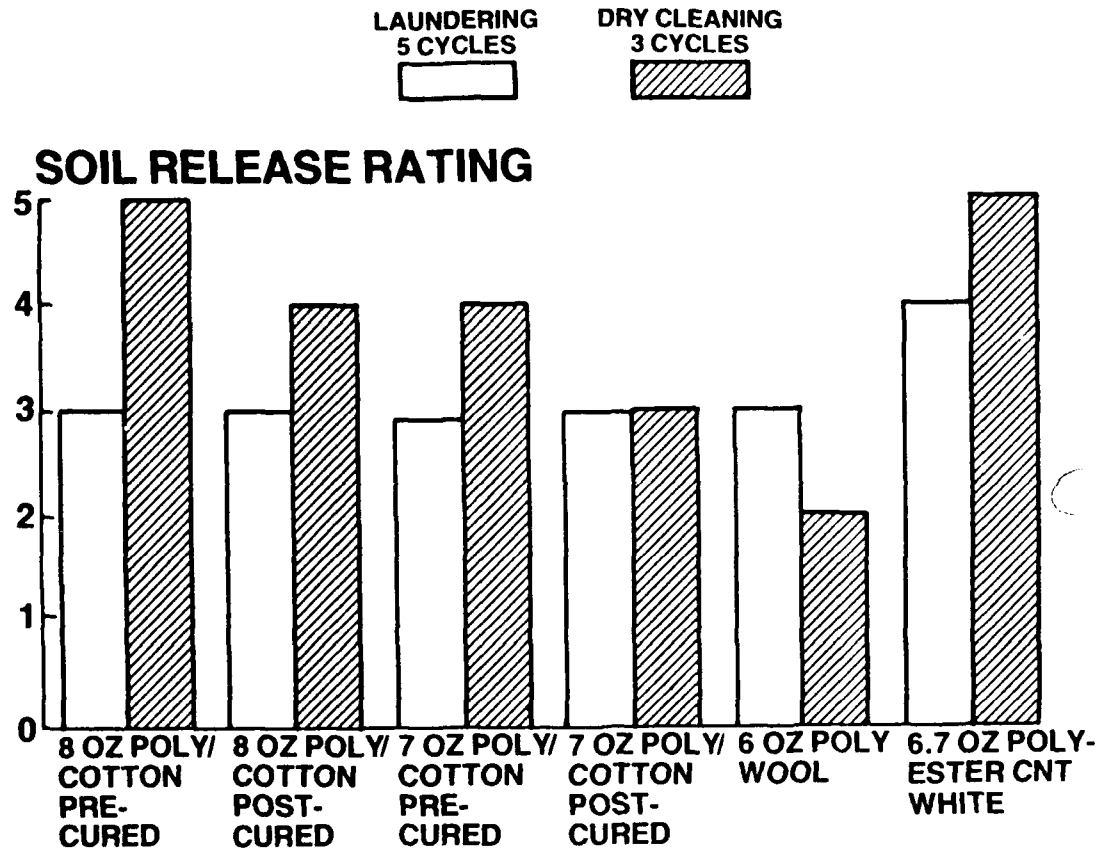

FIGURE 6: SOIL RELEASE RATINGS FOR POLY/CTN AND POLY/WOOL KHAKI FABRICS VERSUS CNT

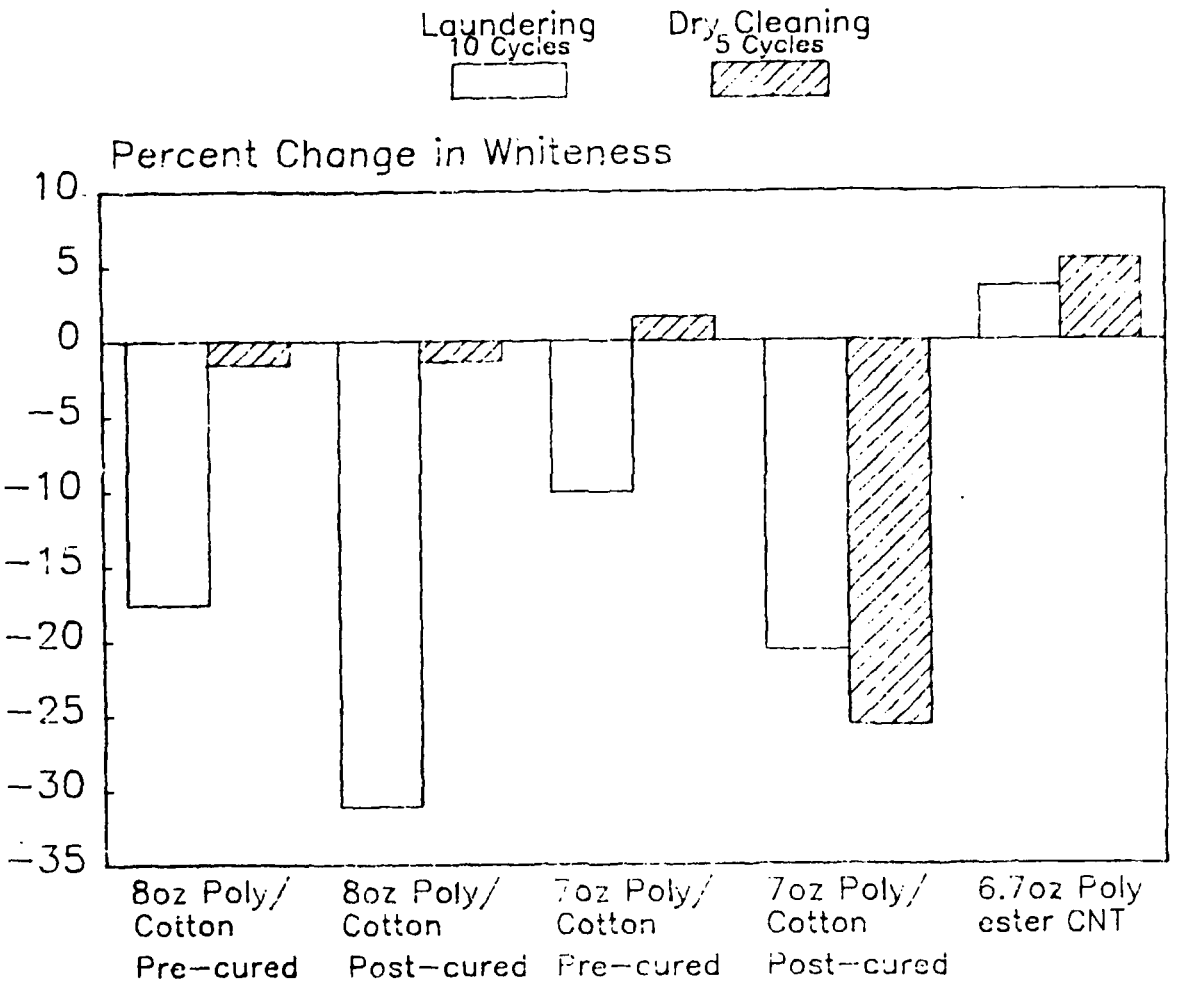

Figure 7: Percent Change in Whiteness for Polyester/Cotton White Fabrics Versus CNT

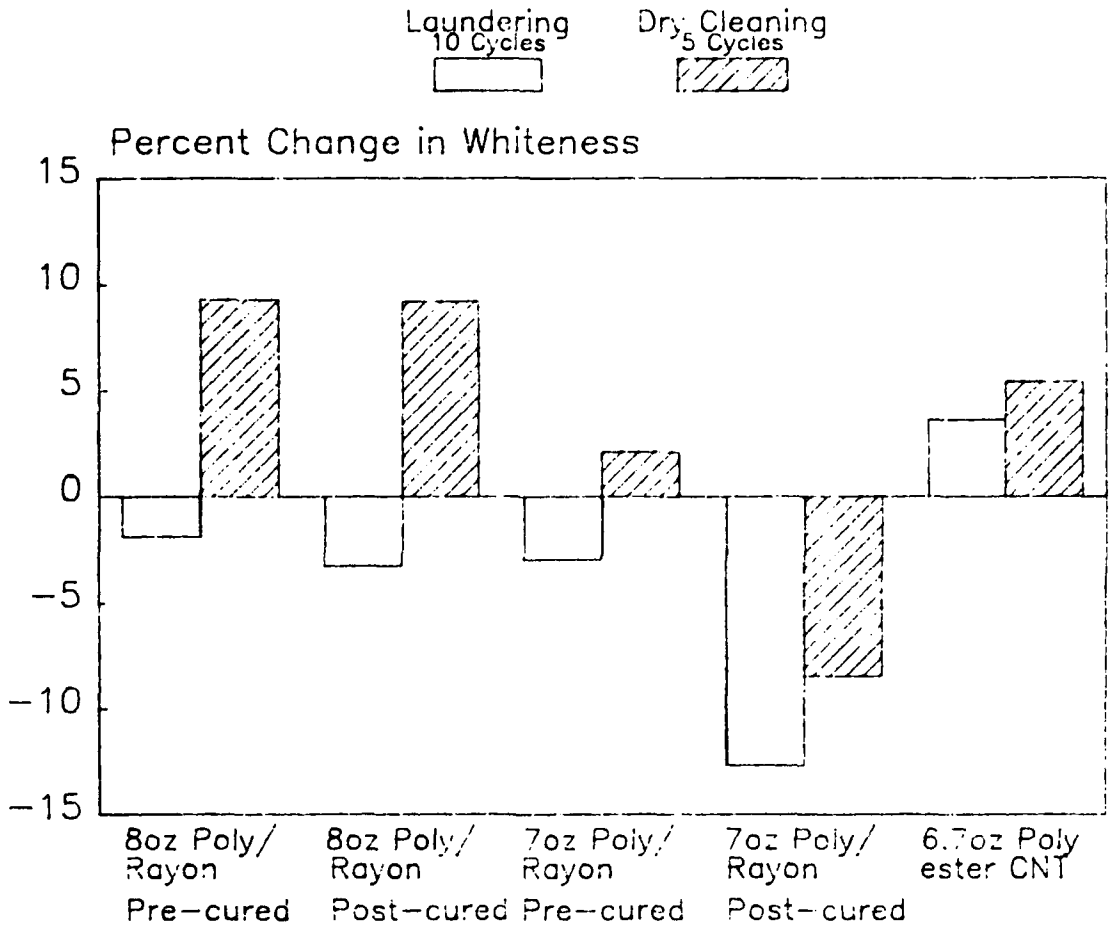

Figure 8: Percent Change in Whiteness for Polyester/Rayon White Fabrics Versus CNT

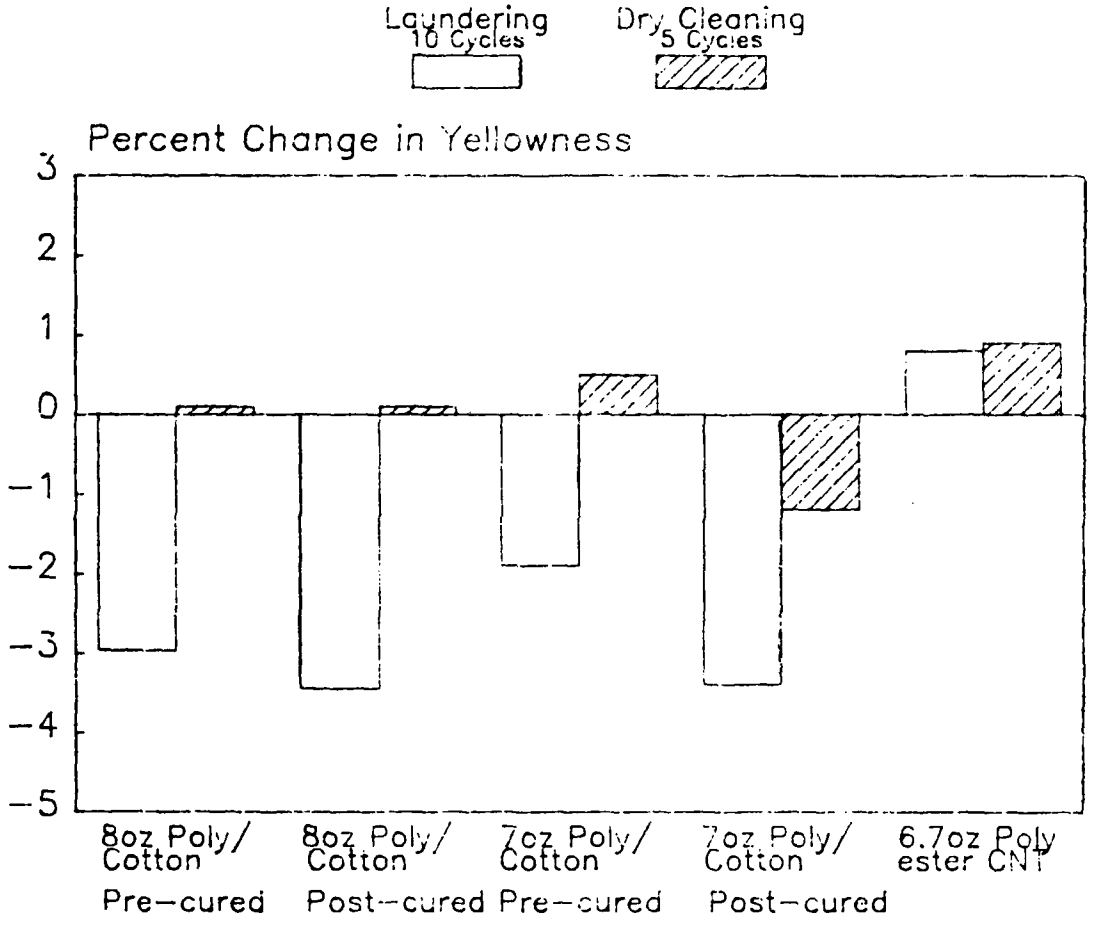

Figure 9: Percent Change in Yellowness for Polyester/Cotton White Fabrics Versus CNT

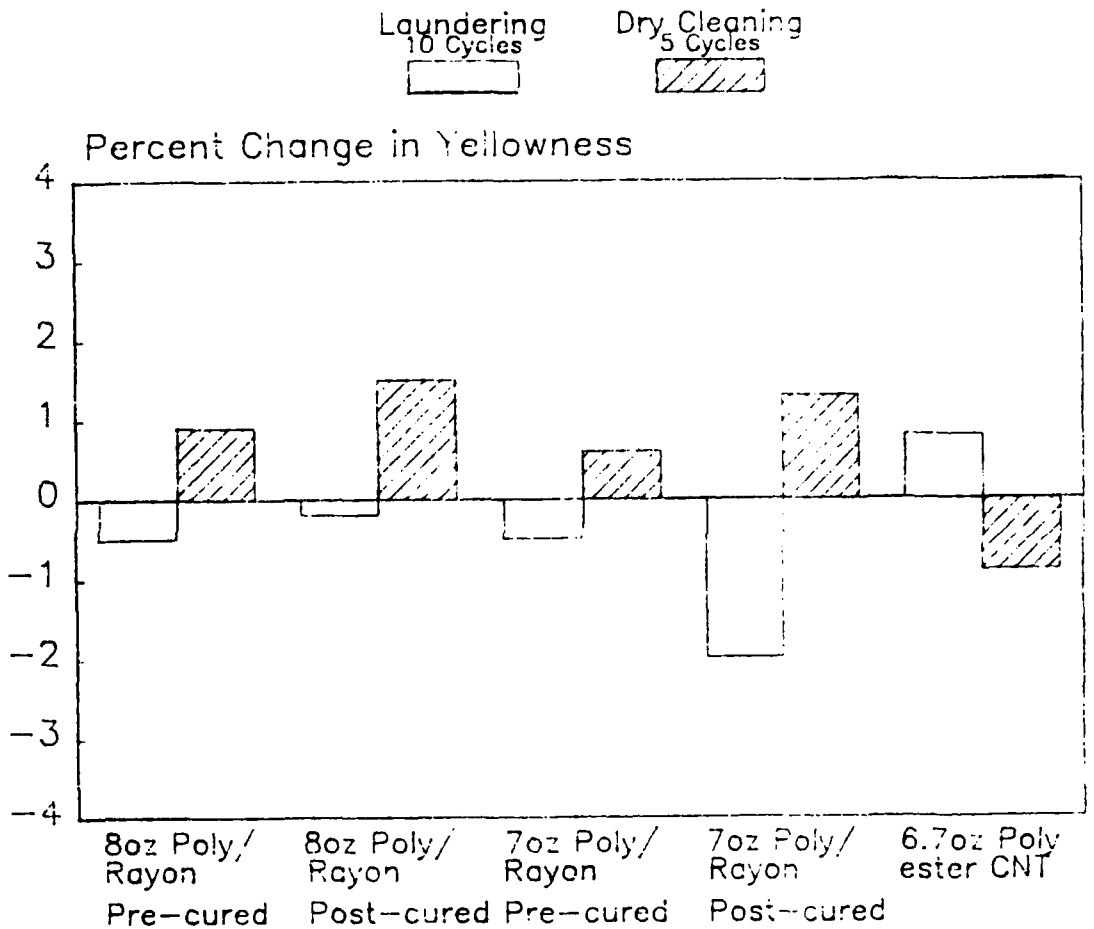

Figure 10: Percent Change in Yellowness for Polyester/Rayon White Fabrics Versus CNT

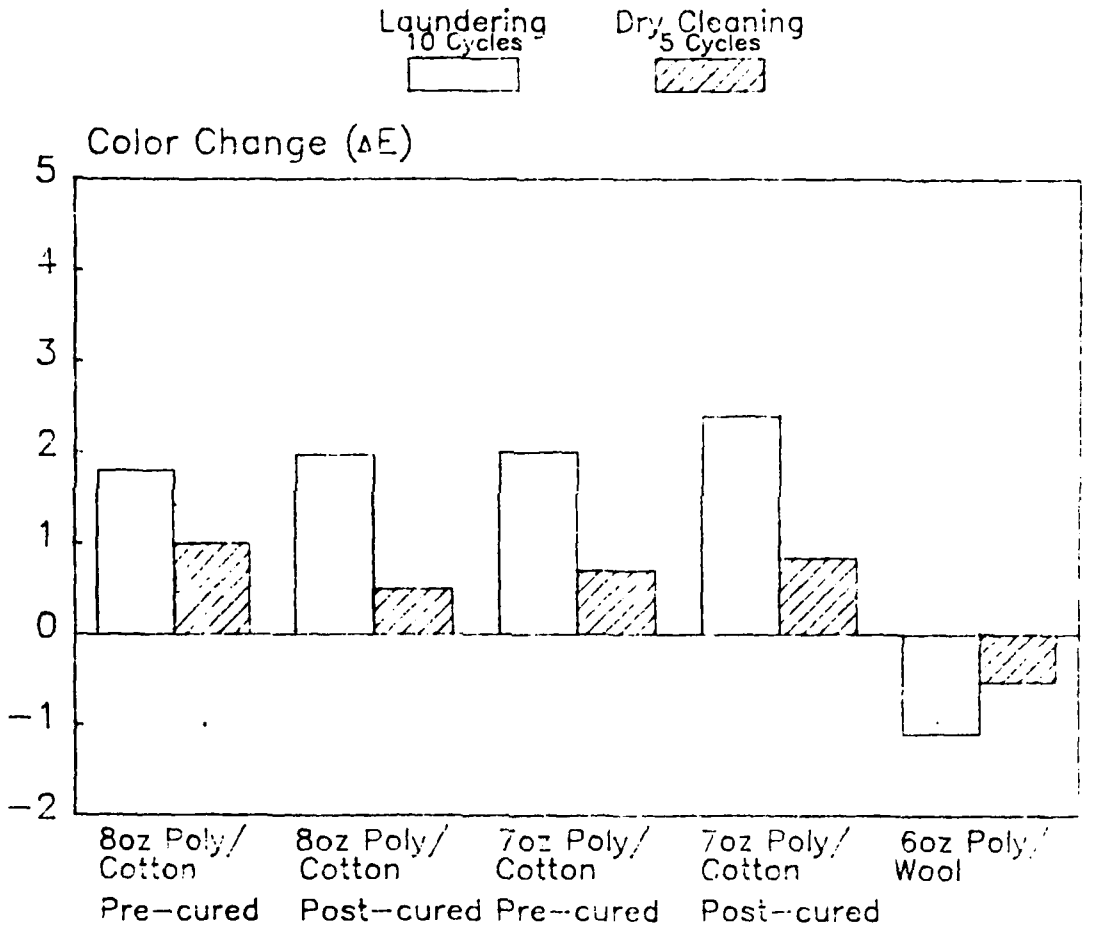

Figure 11: Change in Shade of Khaki Poly/Cotton and Poly/Wool Fabrics

After pressing the average rating for all of the fabrics used in the men's uniforms was greater than 4 indicating that the appearance of all of these fabrics could be properly restored with pressing. For the women's uniforms the average rating for those fabrics evaluated was 4 after pressing, except for the 7 oz/yd^2 polyester/cotton pre-cured fabric which had a 3 rating. Again, for most of the candidate fabrics, suitable appearance could be achieved with pressing.

White Uniforms After Dry Cleaning (Table IX)

Only before pressing results were measured under the dry cleaning condition. The best results were achieved with the polyester/rayon fabrics. Considering all four polyester/rayon fabrics the durable press ratings were slightly less then 4 for all men's and women's uniforms. For the polyester/cotton candidates the ratings were slightly better than 3 for the men's and women's uniforms. So in general non-pressed appearance after dry cleaning was somewhat better for nearly all fabrics when compared to the laundering results.

Khaki Uniforms After Laundering (Table X)

For these uniforms the polyester/rayon fabrics were not used. The candidate fabrics were either polyester/cotton or polyester/wool.

For the men's and women's polyester/cotton uniforms the average durable press rating before pressing was 2.5, and 2.0 and 1.7 respectively for the men's and women's polyester/wool uniforms before pressing.

After pressing the average rating for the polyester/cotton fabrics was 4.0 in the men's uniforms and 4.3 in the women's uniforms, and 5.0 and 4.7 respectively for the men's and women's polyester/wool uniforms. This after pressing data indicates that the appearance of these uniforms can be properly restored when pressed.

Khaki Uniforms After Dry Cleaning (Table XI)

Only non-press data was obtained for the dry cleaning condition. For the polyester/cotton uniforms the average durable press rating was 3.2 for both the men's and women's uniforms. The average rating for the polyester/wool uniforms was 4.0.

As indicated for the white uniforms before press appearance was higher after dry cleaning than after laundering. For the polyester/wool fabric less pressing would be required after dry cleaning to achieve a suitable appearance compared to the polyester/cotton uniforms.

Dimensional Stability

Tables XII and XIII show the dimensional stability data for the white uniforms and Tables XIV and XV for the khaki uniforms after shipboard laundering and dry cleaning.

Table VIII Durable Press Ratingsfor White Uniforms
After Five Laundering Cycles

Fabric	Uniform													
	Men's								Women's					
	Jumper		Jumper Trouser		Dress Coat		Dress Jacket		Dress Coat		Dress Jacket		Dress Skirt	
	BP	AP	BP	AP	BP	AP	BP	AP	BP	AP	BP	AP	BP	AP
8-PC-W-Pr-Sr	2	4	3	4	4	5	3	5						
8-PC-W-Po-SR	3	4	3	4	3	5	3	5	2	4	3	4	2	4
7-PC-W-Pr-Sr	1	4	3	4			3	5	2	3	2	4	2	3
7-PC-W-Po-SR	2	4	2	4	2	4	3	5	3	4	3	4	3	4
8-PR-W-Pr-SR	2	4	2	4	3	5	2	5	2	4	2	4	2	4
8-PR-W-Po-SR	2	4	1	4	3	5	3	5	2	4	2	4	1	5
7-PR-W-Pr-SR	1	4	2	4	3	5	2	5			2	4		
7-PR-W-Po-SR	2	4	1	4	3	5	3	5			2	4		
CNT	1	5	2	5										

Notes:
1. Laundering Procedure - NAVEDTRA Formula II
2. Measurement Procedure - AATCC Test Method 124-1979
3. Legend: BP, Before Pressing; AP, After Pressing
4. Rating Scale
    1. Crumpled, Creased, and Severely Wrinkled Appearance
    2. Rumpled, Obviously Wrinkled Appearance
    3. Mussed, Non-Pressed Appearance
    4. Smooth Finished Appearance
    5. Very Smooth, Pressed, Finished Appearance

Table IX Durable Press Ratings Before Pressing for White Uniforms
After Five Dry Cleaning Cycles

Fabric	Uniform						
	Men's				Women's		
	Jumper	Jumper Trouser	Dress Coat	Dress Jacket	Dress Coat	Dress Jacket	Dress Skirt
8-PC-W-Pr-Sr	3	3	4	3	4	4	3
8-PC-W-Po-SR	4	3	3	3	4	4	3
7-PC-W-Pr-Sr	3	3	4	3	4	4	2
7-PC-W-Po-SR	3	3	3	3	3	3	2
8-PR-W-Pr-SR	3	4	4	3	4	4	3
8-PR-W-Po-SR	4	4	4	4	4	4	3
7-PR-W-Pr-SR	4	4	4	4	4	4	4
7-PR-W-Po-SR	4	4	4	4	4	4	4
CNT	4	4					

Notes:
1. Drycleaning Procedure - AATCC Test Method 158-1979
2. Measurement Procedure - AATCC Test Method 124-1978
3. Rating Scale
    1. Crumpled, Creased, and Severely Wrinkled Appearance
    2. Rumpled, Obviously Wrinkled Appearance
    3. Mussed, Non-Pressed Appearance
    4. Smooth Finished Appearance
    5. Very Smooth, Pressed, Finished Appearance

White Uniforms After Laundering (Table XII)

Dimensional reductions for girth measurements were less than 1.3 percent for all men's and women's uniforms for all of the candidate fabrics except for the chest measurement on the jumper made from the 7 oz/yd^2 polyester/rayon post-cured fabric. For this fabric a reduction of 4.1 percent was measured.

Depending on the uniform component all candidate polyester/cotton fabrics experienced reductions in a particular length dimension of 0.0 to 5.1 percent. The average dimensional reduction was 2.4 percent. The polyester/rayon fabrics experienced length dimensional reductions of 0.0 to 4.8 percent. The average dimensional reduction was 2.4 percent. All length dimensional reductions for uniform components made of CNT were less than 2.0 percent.

White Uniforms After Dry Cleaning (Table XIII)

All girth and length dimensional changes for all fabric/uniform combinations did not exceed 2.0 percent. The effects of dry cleaning on dimensional changes of fabric/uniform combinations was significantly less severe than under the laundering condition.

Khaki Uniforms After Laundering (Table XIV)

All girth dimensional changes were less than 2.0 percent for all fabric/uniform combinations except in two of the women's uniform components. The women's shirt showed a bust dimensional increase of 2.8 percent with the 8 oz/yd^2 polyester/cotton post-cured fabric and the hip dimension of the women's skirt had an increase of 2.7 percent for the 7 oz/yd^2 polyester/cotton pre-cured material and an increase of 5.2 percent for the 6 oz/yd^2 polyester/wool fabric.

Reductions in length dimensions of greater than 2.0 percent occurred in one instance for the 8 oz/yd^2 polyester/cotton post-cured fabric in the side seam of the women's skirt (2.7 percent), in two instances for the 7 oz/yd^2 polyester/cotton post-cured fabric, out seam of men's trousers and side seams of women's skirt (2.1 percent and 2.5 percent respectively), and in all uniform components for the 6 oz/yd^2 polyester/wool fabric (range 2.4 to 2.9 percent).

Khaki Uniforms After Dry Cleaning (Table XV)

Except for the hip dimension in the women's skirt which grew 5.6 percent for the 6 oz/yd^2 polyester/wool fabric, all other dimensional changes in girth or length were less than 2.0 percent.

As with the white uniforms the laundering condition had a more severe effect on dimensional changes in the various fabric/uniform combinations than the dry cleaning condition.

Table X - Durable Press Ratings for Khaki Uniforms After Five Laundering Cycles

Fabric	Uniform									
	Men's				Women's					
	Shirt		Trouser		Shirt		Slack		Skirt	
	BP	AP	BP	AP	BP	AP	BP	AP	BP	AP
8-PC-K-Pr-SR	2	4	3	4			2	4	2	4
8-PC-K-Po-SR	3	4	2	4	3	4			2	5
7-PC-K-Pr-SR	2	4	2	4	3	4	2	4	2	4
7-PC-K-Po-SR	3	4	3	4	3	5	3	5		
6-PW-K	2	5	2	5	1	5	2	5	2	4

Notes:

1. Laundering Procedure - NAVEDTRA Formula II
2. Measurement Procedure - AATCC Test Method 124-1978
3. Legend - BP - Before Pressing; AP - After Pressing
4. Rating Scale
   1 - Crumpled, Creased and Severely Wrinkled Appearance
   2 - Rumpled, Obviously Wrinkled Appearance
   3 - Mussed, Non-Pressed Appearance
   4 - Smooth Finished Appearance
   5 - Very Smooth, Pressed, Finished Appearance

Table XI - Durable Press Ratings Before Pressing for Khaki Uniforms After Five Dry Cleaning Cycles

Fabric	Uniform				
	Men's		Women's		
	Shirt	Trouser	Shirt	Slack	Skirt
8-PC-K-Pr-SR	4	3		3	3
8-PC-K-Po-SR	4	3	4		
7-PC-K-Pr-SR	3	3	3	3	3
7-PC-K-Po-SR	3	3	3	3	3
6-PW-K .	4	4	4	4	4

NOTES:

1. Drycleaning Procedure - AATCC Test Method 158-1979
2. Measurement Procedure - AATCC Test Method 124-1978
3. Rating Scale
   - 1 - Crumpled, Creased and Severely Wrinkled Appearance
   - 2 - Rumpled, Obviously Wrinkled Appearance
   - 3 - Mussed, Non-Pressed Appearance
   - 4 - Smooth Finished Appearance
   - 5 - Very Smooth, Pressed, Finished Appearance

Table XII Dimensional Stability Data for White Uniforms
After Five Laundering Cycles

Fabric	Uniform																				
	Men's												Women's								
	Jumper			Jumper Trouser			Dress Coat			Dress Jacket			Dress Coat			Dress Jacket			Dress Skirt		
	CH	BL	SL	WT	IS	OS	BL	SS	SL	BL	SS	SL	BL	SS	SL	BL	SS	SL	HP	BL	SS
8-PC-W-Pr-SR	+0.5	3.0	2.5	0.0	2.5	2.1	2.1	3.1	3.5	0.0	1.3	1.5									
8-PC-W-Po-SR	+0.5	0.4	1.0	+1.6	1.2	1.2	1.7	3.0	2.0	1.3	3.8	1.9	3.9	4.0	3.6	4.1	3.6	3.3	0.0	3.8	4.1
7-PC-W-Pr-SR	0.0	5.1	3.8	1.3	3.0	3.1				1.0	1.3	0.5	2.4	2.9	3.2	2.8	0.0	2.9	+0.5	2.7	2.5
7-PC-W-Po-SR	0.5	1.6	1.7	0.0	1.5	1.8	0.9	1.3	1.9	2.0	1.1	1.9	3.2	2.4	3.2	2.9	2.4	3.8	+0.5	3.7	3.4
8-PR-W-Pr-SR	1.0	3.0	3.3	1.2	3.3	3.8	1.0	2.0	2.7	0.5	0.0	2.9	3.2	2.9	3.2	3.4	2.9	3.5	1.3	2.6	2.6
8-PR-W-Po-SR	0.5	2.5	1.7	+0.6	3.3	3.8	0.9	1.3	2.4	0.5	0.0	1.0	4.3	4.2	4.0	4.3	3.6	3.7	1.1	4.8	3.8
7-PR-W-Pr-SR	1.3	2.4	1.3	0.6	2.3	2.1	1.3	1.5	4.2	0.5	1.4	1.5				2.9	2.9	2.8			
7-PR-W-Po-SR	4.1	1.6	1.7	0.7	2.0	1.8	1.0	2.5	0.4	1.5	2.6	1.5				3.5	3.6	3.1			
CNT	0.5	0.4	0.8	0.0	1.1	1.9															

Notes:

1. Laundering Procedure - NAVEDTRA Formula II
2. Measurement Procedure - AATCC Test Method 150-1979
   Aplus measurement indicates growth
3. Legend:
   CH - Chest
   WT - Waist
   HP - Hip
   BL - Body Length
   SL - Sleeve Length
   SS - Side Seam
   IS - Inseam
   OS - Outseam

Table XIII Dimensional Stability Data for White Uniforms After Five Dry Cleaning Cycles

Fabric	Uniform															
	Men's										Women's					
	Jumper			Jumper Trouser			Dress Coat		Dress Jacket		Dress Coat		Dress Jacket		Dress Skirt	
	CH	BL	SL	WT	IS	OS	BL	SL	BL	SL	BL	SL	BL	SL	HP	BL
8-PC-W-Pr-SR	0.6	0.0	0.5	0.7	0.7	0.6	0.8	0.5	1.2	0.9	1.0	0.5	1.4	0.0	0.0	0.4
8-PC-W-Po-SR	0.0	0.0	1.0	+0.7	0.4	1.2	0.8	0.9	1.2	0.9	0.5	1.0	0.7	1.0	0.0	1.3
7-PC-W-Pr-SR	0.0	1.0	1.0	0.4	0.0	0.3	0.8	0.5	1.2	0.9	1.0	0.5	0.7	1.0	0.0	1.3
7-PC-W-Po-SR	+0.5	0.0	0.5	+0.8	0.4	0.3	0.8	0.5	1.2	0.9	1.4	1.4	0.7	1.0	0.0	0.9
8-PR-W-Pr-SR	0.6	1.0	0.0	+0.8	0.7	0.6	0.4	0.0	0.0	0.5	0.5	0.5	0.7	1.5	0.6	0.4
8-PR-W-Po-SR	0.0	0.5	0.5	0.4	0.4	0.6	0.8	0.5	0.0	0.5	0.9	0.5	0.0	1.0	0.0	0.9
7-PR-W-Pr-SR	+0.6	0.5	0.0	+0.4	0.7	+0.6	0.4	0.0	0.6	0.9	0.5	0.0	0.0	0.5	0.7	1.2
7-PR-W-Po-SR	1.7	0.5	1.0	0.0	0.7	0.3	1.2	1.4	0.0	0.9	1.0	0.5	0.7	0.0	0.0	0.4
CNT	0.0	0.0	0.5	0.0	1.0	0.0										

Notes:

1. Drycleaning Procedure - AATCC Test Method 158-1979
2. Measurement Procedure - AATCC Test Method 158-1979
   A plus measurement indicates growth.
3. Legend

CH - Chest	BL- Body Length
WT - Waist	SL - Sleeve Length
HP - Hip	IS - Inseam
	OS - Outseam

Table XIV Dimensional Stability Data for Khaki Uniforms After Five Laundering Cycles

Fabric	Uniform														
	Men's						Women's								
	Shirt			Trouser			Shirt			Slack			Skirt		
	CH	BL	SS	WT	IS	OS	BS	BL	SS	HP	IS	SS	HP	PL	SS
8-PC-K-Pr-SR	0.0	0.7	1.3	+0.6	1.4	0.7				0.0	1.9	1.7	+1.1	0.0	1.1
8-PC-K-Po-SR	0.0	1.4	0.6	+1.5	1.5	1.9	+2.8	1.4	0.6				1.4	0.9	2.7
7-PC-K-Pr-SR	0.5	0.9	1.3	+1.5	1.5	1.2	0.0	1.8	1.2	+0.5	1.6	1.4	+2.7	0.0	1.5
7-PC-K-Po-SR	+0.4	1.4	1.3	0.0	1.5	2.1	+1.6	0.7	2.5	+1.7	1.3	0.6			
6-PW-K	1.0	2.7	1.6	+0.6	1.5	2.4	0.0	2.5	1.3	0.0	2.0	2.9	+5.2	1.4	2.5

Notes:

1. Laundering Procedure - NAVEDTRA Formula II
2. Measurement Procedure - AATCC Test Method 150-1979
   A plus measurement indicates growth.
3. Legend

CH - Chest	BL- Body Length
BS - Bust	SS - Side Seam
WT - Waist	IS - Inseam
HP - Hip	OS - Outseam

Table XV - Dimensional Stability Data for Khaki Uniforms After Five Dry Cleaning Cycles

Fabric	Uniform											
	Men's					Women's						
	Shirt		Trouser			Shirt		Slack			Skirt	
	CH	BL	WT	IS	OS	BS	BL	HP	IS	SS	HP	BL
8-PC-K-Pr-SR	0.0	0.4	0.0	1.1	0.3			0.0	0.4	0.3	+1.3	0.4
8-PC-K-Po-SR	0.0	0.4	0.0	0.4	0.3	0.6	0.9					
7-PC-K-Pr-SR	1.1	0.0	0.0	1.1	0.3	+0.5	0.4	0.0	0.8	0.6	+0.6	+0.9
7-PC-K-Po-SR	0.6	0.4	0.3	0.0	0.3	0.0	0.5	0.0	0.4	0.6	0.0	0.4
6-PW-K	0.0	0.0	+0.7	0.7	0.6	+1.9	0.9	+1.3	0.4	0.6	+5.6	

Notes:

1. Drycleaning Procedure - AATCC Test Method 158-1979
2. Measurement Procedure - AATCC Test Method 158-1979
   A plus measurement indicates growth.
3. Legend

CH - Chest	BL - Body Length
BS - Bust	SS - Side Seam
WT - Waist	IS - Inseam
HP - Hip	OS - Outseam

Silicone Crease Results

Results are shown in Table XVI. The silicone crease formed in the pre-cured polyester/cotton men's khaki trousers had an excellent sharp initial appearance while creases formed in post-cured polyester/cotton men's khaki trousers had a good semi-sharp initial appearance. After five shipboard launderings and commercial dry cleanings the silicone crease had a semi-sharp good appearance both before and after pressing while the post-cured fabrics had a poor appearance prior to pressing and a fair appearance after pressing.

User Evaluation of Uniforms

Results of the user evaluation are shown in Tables XVII, XVIII, and XIX. The data shown indicates the total number of responses to a particular characteristic addressed for each candidate fabric evaluated and a breakdown of the number of responses associated with a particular attribute regarding an individual characteristic expressed as a percentage of the total responses for that characteristic.

Only two uniform configurations were evaluated; summer khaki and service dress white jumpers. The participants included 29 officer and 10 enlisted male personnel. The khaki uniforms were worn an average of ten times ranging from 7 to 15 times depending upon the particular fabric candidate evaluated. The white jumper uniforms were worn an average of five times ranging from 2 to 16 times depending upon the particular fabric candidate evaluated. The temperature and relative humidity conditions during the evaluation period ranged between 80 and 90 deg. F and greater than 50 percent, respectively.

Summer Khaki Uniforms (Table XVII)

Initial Fit - Depending upon the particular candidate fabric, responses indicated the fit of the uniforms was considered acceptable by as few as 56 percent and as many as 83 percent. For those uniforms where the fit was not considered acceptable ten of the uniforms were made from the polyester/cotton fabrics and seven were made from the polyester/wool fabric.

Laundering Method - Responses indicated that home laundering was the method used by most participants to clean their uniforms. Depending upon the particular fabric 70 to 90 percent home laundered their test uniforms. The remainder had their uniforms laundered commercially.

Degree of Dimensional Change - The majority of the responses, 92 percent or more, indicated that participants did not observe any dimensional changes in their test uniforms for any candidate fabric. Those who did, felt the changes were slight.

Stain Removal - Most responses, at least 83 percent, indicated that stain removal was easy for all candidate fabrics. For two fabrics, (the 8 oz/yd^2 polyester/cotton post-cured, and the 7 oz/yd^2 polyester/cotton pre-cured) 100 percent of the responses indicated that stain removal was easy.

Ironing Required - For all candidate fabrics the majority of the responses, at least 75 percent, indicated that ironing was required to achieve an acceptable appearance. Responses which indicated that no ironing was needed involved uniforms made from the post-cured polyester/cotton fabrics and the polyester/wool candidate. Comments regarding the degree of ironing required ranged from "light touch-up" to "extensive" for all the candidate fabrics.

Appearance After Wear/Cleaning - The only candidate fabric where a majority of the responses (59 percent) indicated that the appearance was acceptable after wear/cleaning was the polyester/wool fabric. Of 50 negative comments received most indicated the garments wrinkled after short periods of wear. Other negative comments indicated that creases degraded or the garments did not provide a good military appearance. These comments covered all candidate fabrics. There were a few positive responses regarding the silicone crease. Four respondents liked the sharpness and durability of the crease.

Durability - At least 92 percent of the responses indicated that the candidate fabrics were durable.

Comfort - The only candidate fabric where a majority of the responses indicated that participants felt cool was the polyester/wool fabric (71 percent). For the polyester/cotton candidate fabrics 58 to 70 percent of the responses indicated that the uniforms were hot. Most of the negative comments received indicated that the uniforms felt hot or heavy.

Comparison to CNT - At least 83 percent of the responses indicated that the polyester/cotton candidates were worse than CNT, while for the polyester/wool candidate 65 percent of the responses indicated that this candidate was worse than CNT. Comments received regarding why CNT was preferred ranged from better appearance, more confortable, better fit, and easier to maintain.

Cost Acceptability - For any particular candidate fabric the maximum "yes" response was for the $34 cost range. In the $40 cost range the significant "yes" responses were for the 8 oz/yd^2 polyester/cotton pre-cured and the polyester/wool candidate fabrics (25 and 29 percent respectively). For the $58 cost range "yes" responses were only received for the polyester/wool candidate. However, only 6 percent of the responses indicated that participants would pay this price.

Preference - The only candidate fabric preferred according to the majority of the responses was the polyester/wool candidate (81 percent). The 8 oz/yd^2 polyester/cotton pre-cured candidate with the silicone creases in the trousers was the second preferred candidate. However, only 27 percent of the responses indicated this fabric was preferred.

White Jumper Uniforms (Tables XVIII and XIX)

The responses for the polyester/cotton fabrics are shown in Table XVIII, and for the polyester/rayon fabrics in Table XIX. Of the twenty uniforms evaluated by 10 volunteers, 17 were polyester/cotton and 3 were polyester/rayon.

Initial Fit - At least 67 percent of the responses indicated an acceptable fit. For those uniforms where the fit was not considered acceptable the fabrics were polyester/cotton.

Laundering Methods - Considering all fabrics, most responses indicated the uniforms were commercially washed. The remaining responses indicated the uniforms were home laundered.

Degree of Dimensional Change - Responses for all candidate fabrics indicated either no dimensional change or a slight dimensional change.

Stain Removal - Responses for all candidate fabrics indicated that stain removal was easy.

Ironing Required - At least 67 percent of the responses for any particular fabric indicated that ironing was required. Responses which indicated that no ironing was needed involved post-cured polyester/cotton uniforms. Comments regarding the degree of ironing required ranged from "light touch-up" to "extensive" for the polyester/cotton fabrics and "regular" to "extensive" for the polyester/rayon fabrics.

Appearance After Wear/Cleaning - The two responses received for the polyester/rayon uniforms indicated acceptable appearance. For the polyester/cotton uniforms at least 50 percent of the responses depending upon the particular fabric indicated appearance was poor. Of 22 negative comments received most indicated the garments wrinkled after short periods of wear. Other comments indicated the garments did not provide a good military appearance.

Durability - Responses for all candidate fabrics indicated that the uniforms were durable.

Comfort - Of the total twenty responses obtained, one response for the 7 oz/yd^2 polyester/cotton pre-cured and one for the 8 oz/yd^2 polyester/rayon post-cured uniforms indicated that the participants were cool. Most of the other responses (10) indicated the uniforms were warm. The other eight responses indicated the uniforms were hot. Of eight comments received, seven indicated that the polyester/cotton fabrics were "too hot" or "too heavy". The other response indicated that 7 oz/yd^2 polyester/rayon post-cured fabric was "too hot".

Comparison to CNT - For the polyester/cotton uniforms, most of the responses for the 8 oz/yd^2 fabrics and the 7 oz/yd^2 pre-cured fabric indicated that CNT was better. For the 7 oz/yd^2 polyester/cotton post-cured fabric two of three responses indicated that the polyester/cotton fabric was equal to or better than CNT. Of two responses for the 7 oz/yd^2 polyester/rayon candidate, one indicated that the pre-cured fabric was better than CNT and one indicated the post-cured fabric was worse than CNT.

Preference - The only fabric where the majority of responses (3 of 3) indicated that it was preferred to the others evaluated was the 8 oz/yd^2 polyester/cotton pre-cured fabric. Of the remaining polyester/cotton fabrics only 4 of 12 responses indicated they were preferred. The three responses for the polyester/rayon fabrics indicated they were not preferred.

Table XVI Relative Appearance of Silicone Creases in Comparison to Creases Formed in Post-Cured Fabrics in Khaki Trousers

Condition	Material							
	8 oz/yd^2 Poly/Cotton				7 oz/yd^2 Poly/Cotton			
	Silicone		Post-Cure		Silicone		Post-Cure	
	BP	AP	BP	AP	BP	AP	BP	AP
Initially	-	Excel	-	Good	-	Excel	-	Good
5 - Shipboard Launderings	Good	Good	Poor	Fair	Good	Good	Poor	Fair
5 - Commercial Dry Cleanings	Good	Good	Poor	Fair	Good	Good	Poor	Fair

Notes BP - Before Pressing
AP - After Pressing

Table XVII Questionnaire Data for Summer Khaki Uniforms
Showing Number of Responses (NR) and Percentage Values (%)

Characteristic	Descriptor	Fabric Type									
		8-PC-K-Pr-SR		8-PC-K-Po-SR		7-PC-K-Pr-SR		7-PC-K-Po-SR		6-PW-K	
		NR	%	NR	%	NR	%	NR	%	NR	%
Initial Fit	Good to Excellent	12	67	12	83	9	56	10	80	17	65
	Poor		33		17		44		20		35
Laundering Method	Home	12	71	12	80	9	70	10	90	17	79
	Commercial		29		20		30		10		21
Degree of Dimensional Change	None	12	92	12	92	9	100	10	100	17	94
	Slight		8		8		0		0		6
	Substantial		0		0		0		0		0
Stain Removal	Easy	10	90	10	100	5	100	6	83	12	92
	Difficult		10		0		0		17		8
Ironing Required	Yes	12	100	12	75	9	100	10	90	17	76
	No		0		25		0		10		24
Appearance After Wear/ Cleaning	Good to Excellent	12	42	12	25	9	33	10	40	17	59
	Poor		58		75		67		60		41
Durability	Good to Excellent	11	100	12	92	7	100	9	100	17	100
	Poor		0		8		0		0		0
Comfort	Hot	12	58	12	58	9	67	10	70	17	29
	Warm		25		17		33		30		0
	Cool		17		25		0		0		71
Comparison to CNT	Worse	12	83	12	92	9	100	10	90	17	65
	Same		17		8		0		10		29
	Better		0		0		0		0		6
Cost Acceptability (Yes)	$58.00	12	0	12	0	9	0	10	0	17	6
	$40.00		25		8		0		10		29
	$34.00		33		8		22		20		41
Preference	Yes	11	27	10	20	7	0	9	11	16	81
	No		73		80		100		89		19

Table XVIII Questionnaire Data for White Jumper Uniforms
Showing Number of Responses (NR) and Percentage Values (%)
for Polyester/Cotton Fabrics

Characteristic	Descriptor	Fabric Type							
		8-PC-W-Pr-SR		8-PC-W-Po-SR		7-PC-W-Pr-SR		7-PC-W-Po-SR	
		NR	%	NR	%	NR	%	NR	%
Initial Fit	Good to Excellent	4	75	6	67	4	100	3	67
	Poor		25		33		0		33
Laundering Method	Home	4	25	6	43	4	50	3	33
	Commercial		75		57		50		67
Degree of Dimensional Change	None	4	100	6	83	4	75	3	100
	Slight		0		17		25		0
	Substantial		0		0		0		0
Stain Removal	Easy	4	100	6	100	4	100	3	100
	Difficult		0		0		0		0
Ironing Required	Yes	4	100	6	83	3	100	3	67
	No		0		17		0		33
Appearance After Wear/ Cleaning	Good to Excellent	4	25	5	40	4	50	3	33
	Poor		75		60		50		67
Durability	Good to Excellent	3	100	5	100	3	100	3	100
	Poor		0		0		0		0
Comfort	Hot	4	25	6	50	4	25	3	67
	Warm		75		50		50		33
	Cool		0		0		25		0
Comparison to CNT	Worse	4	100	6	66	3	67	3	33
	Same		0		17		0		33
	Better		0		17		33		33
Preference	Yes	3	100	6	50	3	33	3	0
	No		0		50		67		100

Table XIX Questionnaire Data for White Jumper Uniforms
Showing Number of Responses (NR) and Percentage Values (%)
for Polyester/Rayon Fabrics

Characteristic	Descriptor	Fabric Type					
		8-PR-W-Po-SR		7-PR-W-Pr-SR		7-PR-W-Po-SR	
		NR	%	NR	%	NR	%
Initial Fit	Good to Excellent Poor	1	100 0	1	100 0	1	100 0
Laundering Method	Home Commercial	1	0 100	1	100 0	1	50 50
Degree of Dimensional Change	None Slight Substantial	1	0 100 0	1	0 100 0	1	100 0 0
Stain Removal	Easy Difficult	1	100 0	1	100 0	1	100 0
Ironing Required	Yes No			1	100 0	1	100 0
Appearance After Wear/ Cleaning	Good to Excellent Poor	1	100 0	1	100 0		
Durability	Good to Excellent Poor	1	100 0	1	100 0		
Comfort	Hot Warm Cool	1	0 0 100	1	0 100 0	1	100 0 0
Comparison to CNT	Worse Same Better			1	0 0 100	1	100 0 0
Preference	Yes No	1	0 100	1	0 100	1	0 100

Discussion of Results

Table XX reflects the relative ratings for the candidate fabrics and CNT for the characteristics indicated. A five point rating system was employed. The criteria used in developing the ratings are given in Appendix C. Whole number ratings were used. For example, a rating of 3.5 was rounded to 4, a rating of 3.4 was rounded to 3.

Where applicable laundering data was employed rather than dry cleaning data because in most instances laboratory laundering data produced the lowest ratings and in the user evaluation all of the participants laundered their uniforms.

Ratings for pre-cured or post-cured fabrics were pooled because the advantage of one process versus the other in terms of the characteristics indicated tended to vary within a specific characteristic. Therefore there was no definitive differences between these two processes except for judging the efficacy of using a silicone resin to improve crease durability which will be discussed separately further on.

Data for white and khaki fabrics and uniforms were also pooled except for those characteristics directly related to shade. Whiteness and yellowness changes in white fabrics and shade change in khaki fabrics. For the user evaluation results, the data for the polyester/rayon fabrics were not shown because only three white jumper uniforms were evaluated in two of the polyester/rayon fabrics.

Strength/Durability - Based upon both laboratory and user data all candidate fabrics had good strength and durability and were rated 5. There were no definitive differences with respect to these properties. CNT was also rated 5 based upon its strength characteristics.

Air Permeability - There were definitive differences in the candidate fabrics regarding this property. The heavier polyester/cotton fabrics were rated 2 having air permeabilities between 11 and 20 $ft^3/min/ft^2$, the lighter polyester/cotton and the heavier polyester/rayon fabrics were rated 3 having air permeabilities between 21 and 30 $ft^3/min/ft^2$. The lighter weight polyester/rayon fabrics and the polyester/wool candidate were rated 4 having air permeabilities between 31 and 40 $ft^3/min/ft^2$. CNT was rated 5 with an air permeability between 41 and 50 $ft^3/min/ft^2$.

Dimensional Stability - Laboratory ratings for this characteristic for materials and garments showed some differences.

All of the candidate fabrics tested in material form except the heavier polyester/cotton fabrics were rated 3 indicating that where applicable either the pre or post-cured version or both showed a dimensional change of between 2.1 and 3.0 percent. The heavier polyester/cotton fabrics had a 4 rating with a maximum dimensional change between 1.1 and 2.0 percent. CNT was also rated 4 based upon a dimensional change between 1.1 and 2.0 percent.

In the laboratory garment tests all fabrics except the heavier polyester/rayon fabric were rated 4 (dimensional change between 1.1 and 2.0 percent). The heavier polyester/rayon fabric was rated 3 (dimensional change between 2.1 and 3.0 percent). CNT was also rated 4 (dimensional change 1.1 to 2.0 percent).

In developing the rating for any particular fabric in garment form the maximum girth dimensional change for each uniform type was rated and the results averaged and the maximum length dimensional change for each uniform type was rated and the results averaged. The girth and length averages were then pooled to obtain an overall average rating for each candidate fabric for the various uniforms which had been fabricated from the fabric.

In the user evaluation all of the evaluated fabrics were rated 5 because 81 to 100 percent of the participants indicated there were no dimensional changes in the uniforms they evaluated.

Appearance - Based on the standard durable press ratings all candidate materials were rated 4 including CNT indicating a smooth finished appearance after laundering and before pressing. In garment form ratings dropped 1 to 2 points with the polyester/cotton candidates having a 3 rating (mussed, non-pressed appearance) and the remaining candidates and CNT having a 2 rating (rumpled, obviously wrinkled appearance).

As in the dimensional stability ratings of garments each garment type for each fabric was rated individually and an average rating computed.

In the user evaluation ratings were determined on the basis of the percentage of responses which indicated that appearance after cleaning/wear was good to excellent. Based on this criteria the polyester/cotton fabrics were rated 2 (21 to 40 percent of the responses good to excellent) and the polyester/wool fabric was rated 3 (41 to 60 percent of the responses good to excellent).

Soil Release - Cleanability of stained fabrics laundered in garment form indicated that all candidate fabrics were similarly effective. All were rated 3. CNT was rated 4 for this characteristic.

In the user evaluation soil release ratings were based on the percentage of responses which indicated the fabrics were "easy to clean". For the fabrics evaluated, polyester/cotton and polyester/wool, all were rated 5 (81 to 100 percent of the responses indicated that the fabrics were "easy to clean").

Discoloration (Whites Only)

Whiteness Change - The polyester/rayon and CNT fabrics were rated 5. Reduction in whiteness was less than 10 percent. The heavier polyester/cotton fabrics were rated 3 (percent reduction in whiteness between 21 and 30 percent) and the lighter polyester/cotton fabrics were rated 4 (percent reduction in whiteness between 11 and 20 percent).

Yellowness Change - All candidate fabrics and CNT were rated 5. Increase in yellowness was less than 10 percent for all fabrics.

Shade Change (Khaki Only) - The khaki fabrics candidates were polyester/cotton and polyester/wool. Shade change for the polyester/cotton fabrics was more severe than for the polyester/wool fabric. The polyester/cotton fabrics were rated 1 (ΔE values between 1.7 and 2.0), the polyester/wool fabric was rated 3 (ΔE value between 0.9 and 1.2). The polyester/cotton fabrics became basically lighter after laundering while the polyester/wool fabric became darker.

Comfort - This characteristic was rated on the basis of the percentage of the total responses which indicated "cool". With respect to this characteristic the polyester/cotton fabrics were rated 1 (less than 20 percent of the responses indicated that participants were cool in uniforms made from these fabrics). The polyester/wool fabric was rated 4 (61 to 80 percent of the responses indicated participants were cool in uniforms made from this fabric).

Comparison to CNT - This characteristic was rated on the basis of the percentage of the total responses which indicated that the candidate fabric/uniform was the "same or better" than CNT uniforms. The polyester/wool fabric was rated 2 (21 to 40 percent of the responses indicated the uniforms made from these fabrics were equal to or better than CNT). The polyester/cotton uniforms were rated 1 (less than 20 percent of the responses indicated the uniforms made from this fabric were equal to or better than CNT).

Preference - These ratings reflect the relative preference between the candidate fabrics. The polyester/wool fabric had the highest preference and was rated 4 (61 to 80 percent of the responses indicated this fabric was preferred). The heavier polyester/cotton fabric was rated 2 (21 to 40 percent of the total responses indicated this fabric was preferred) and the lighter polyester/cotton fabric was rated 1 (less than 20 percent of the total responses indicated this fabric was preferred).

Other Comments - Ratings were totaled based on laboratory data only including ratings for discoloration of whites and excluding ratings for shade change for khaki, laboratory data only including ratings for shade change in khakis and excluding discoloration ratings of whites, and laboratory and user data of polyester/cotton and polyester/wool fabrics excluding discoloration and shade change ratings. These total ratings are indicated in Table XXI.

From the rating totals indicated in Table XXI it can be seen that in laboratory evaluations that CNT performed somewhat better than the polyester/cotton and polyester/rayon fabrics with the lighter polyester/cotton and polyester/rayon fabrics performing slightly better than their heavier counterparts, and that the polyester/wool fabric performed somewhat better than the two polyester/cotton fabrics which were essentially equivalent. When combining the user and laboratory evaluation data the polyester/wool fabric had a significantly higher total rating with respect to the polyester/cotton fabrics.

Silicone Creases - Based upon laboratory results, the silicone creases formed in the pre-cured polyester/cotton khaki uniform trousers were considered superior in both sharpness and durability with respect to creases formed by conventional means in post-cured polyester/cotton khaki uniform trousers.

Table XX Relative Rating for Candidate Fabrics and CNT for Each Characteristic Indicated. Weights Where Applicable have been Average for the Pre-Cured and Post-Cured Equivalent Fabrics

Characteristic	Eval. Type	Polyester/Cotton (oz/yd^2)		Polyester/Rayon (oz/yd^2)		Polyester/Wool (oz/yd^2)	CNT (oz/yd^2)
		8.5	7.6	8.8	7.3	6.6	6.7
Strength/Durability	Lab	5	5	5	5	4	5
	User	5	5	-	-	5	-
	AVG	5	5	5	5	5	5
Air Permeability	Lab	2	3	3	4	4	5
Dimensional Stability, Laundering	Lab/Mat	4	3	3	3	3	4
	Lab/Gar	4	4	3	4	4	5
	User	5	5	-	-	5	-
	AVG	4	4	3	4	4	5
Appearance Laundering	Lab/Mat Non Pressed	4	4	4	4	4	4
	Lab/Gar Non Pressed	3	3	2	2	2	2
	User	2	2	-	-	3	-
	AVG	3	3	3	3	3	3
Soil release, Laundering	Lab/Gar	3	3	3	3	3	4
	User	5	5	-	-	5	-
	AVG	4	4	3	3	4	4
Discoloration, Laundering	Whiteness	3	4	5	5	-	5
	Yellowness	5	5	5	5	-	5
	AVG	4	5	5	5	-	5
Shade Change, Laundering	Lab/Gar	1	1	-	-	3	-
Comfort	User/Cool	1	1	-	-	4	-
Comparison to CNT	User/Same or Better	1	1	-	-	2	-
Preference	User	2	1	-	-	4	-

Table XXI Rating Totals for Candidate Fabrics and CNT Weights Where Applicable Have Been Averaged for the Pre-Cured and Post-Cured Equivalent Fabrics

Condition	Poly/Cotton (oz/yd^2)		Poly/Rayon (oz/yd^2)		Poly/Wool (oz/yd^2)	CNT (oz/yd^2)
	8.5	7.6	8.8	7.3	6.6	6.7
Laboratory Eval. Including Discolor. of Whites	22	24	22	24	-	27
Laboratory Eval. Including Shade Change in Khaki	19	20	-	-	23	-
Laboratory and User Eval. Excluding Discolor. and Shade Change	22	22	-	-	30	-

Overall Results

Laboratory - The polyester/cotton fabrics when compared to the polyester/rayon fabrics performed similarly, the lighter weight counterparts performing slightly better than their heavier weight counterparts with CNT showing the best performance.

The polyester/wool fabric when compared to the polyester/cotton fabrics performed better with polyester/cotton fabrics performing similarly.

Laboratory/User Evaluation - The polyester/wool fabric was superior when compared to the polyester/cotton fabrics with the polyester/cotton fabrics performing similarly. The polyester/wool fabric being significantly lighter and more air permeable than the polyester/cotton fabrics were apparently the major causes for it outperforming the polyester/cotton fabrics when user evaluation results were included.

White Uniform Applications - Based upon the laboratatory and field evaluations both the polyester/cotton and polyester/rayon fabrics would be expected to be similar in performance. However, to achieve a suitable degree of acceptance by Naval personnel the weight and air permeability of the fabrics would have to be similar to CNT.

The candidate polyester/cotton and polyester/rayon fabrics weighed 0.6 to 2.1 oz/yd^2 more than CNT and their air permeabilities were at least 10 $ft^3/min/ft^2$ less than CNT.

Khaki Uniform Applications - Based upon laboratory and field results the performance of the polyester/wool fabric was superior to the polyester/cotton fabrics. It would appear that this superiority was essentially related to the better comfort the polyester/wool provided with respect to the polyester/cotton candidates. The polyester/wool fabric was 1.0 to 1.9 oz/yd^2 lighter than the polyester/cotton fabrics and its air permeability was at least 11 $ft^3/min/ft^2$ greater than the polyester/cotton fabrics.

Based upon user comments regarding cost factors and comparison to CNT, the acceptability of the polyester/wool fabric is questionable. Less than 6 percent indicated they were willing to pay $58.00 for this uniform and only 35 percent of the responses received indicated that the polyester/wool uniform was equal to or better than CNT.

Other than continuing to use CNT in these uniforms it would appear that either a pre-cured polyester/cotton or polyester/rayon fabric having weight and air permeability properties similar to CNT and containing creases formed with a silicone resin would be a more practical fabric choice.

CONCLUSIONS

White Uniform Applications

a) Under laboratory test conditions the polyester/cotton and polyester/rayon candidate materials performed similarly when the combined results for characteristics such as strength, air permeability, dimensional stability, soil release, and discoloration are considered. Results for the light weight versions of these materials, 7.6 oz/yd^2 polyester/cotton and 7.3 oz/yd^2 polyester/rayon were considered slightly better than their heavier counterparts, 8.5 oz/yd^2 polyester/cotton and 8.8 oz/yd^2 polyester/rayon, primarily because the air permeability of the lighter fabrics was higher. In rating CNT with respect to these same characteristics its performance was considered somewhat better.

b) Results from the user evaluation of the polyester/cotton fabrics in the jumper configuration indicated poor acceptance of these fabrics with respect to comfort, comparison to CNT and individual preference. Less than 10 percent of the total responses indicated the participants were cool in the uniforms, only 30 percent of the total responses indicated personnel felt these uniforms were equal to or better than CNT, and less than 50 percent of the total responses indicated that personnel had a preference for these uniforms.

c) Based on the laboratory results and user evaluations the following inferences can be made:

1. The polyester/rayon materials would have the same degree of poor acceptability as the polyester/cotton materials because of their similar characteristics.

2. Poor acceptance by user personnel was apparantly related in part to the heavier weight and lower air permeabilities of the polyester/cotton materials with respect to CNT and that they wrinkled after short periods of wear. CNT weighs 6.7 oz/yd^2 and has an air permeability at least 29 percent higher than either the polyester/cotton or polyester/rayon candidates.

3. To achieve a better degree of acceptability of polyester/cotton materials with respect to CNT a lighter and more air permeable fabric which mimics these properties of CNT is required and finished with durable press and soil release resins as were the polyester/cotton and polyester/rayon fabrics evaluated in this study to maximize appearance and soil removal.

4. The E-1 summer white trouser 65/35 polyester/cotton fabric closely mimics CNT in terms of weight and air permeability and if finished with both a durable press and soil release resins should be found more acceptable by Naval personnel than the polyester/cotton and polyester/rayon fabrics evaluated in this study. However the appearance achieved will not be as stable after wear as with the CNT fabric.

Khaki Uniform Applications

a) Under laboratory test conditions the polyester/wool candidate material performed somewhat better than the polyester/cotton candidates when the combined results for characteristics such as strength, air permeability, dimensional stability, soil release, and shade change are considered. Principal differences were higher air permebility (at least 26 percent higher than the polyester/cotton candidates) and less shade change after laundering with the polyester/wool fabric.

b) Results from the user evaluation of summer khaki uniforms indicated the polyester/wool fabric was more acceptable than the polyester/cotton fabrics with respect to comfort and user preference. Responses indicated that 71 percent felt cool in the polyester/wool uniforms versus 25 percent or less for the polyester/cotton uniforms, and 81 percent of the responses indicated the polyester/wool uniform was preferred versus 27 percent or less for the polyester/cotton uniforms. These differences are not surprising when one considers that the polyester/wool candidate was at least 1 oz/yd^2 lighter than the polyester/cotton fabrics and similar to CNT in this respect and as indicated earlier at least 26 percent more air permeable than the polyester/cotton material.

c) The overall acceptability of the polyester/wool fabric appears questionable even though its performance compared to the polyester/cotton fabrics was superior in the user evaluation. User evaluation data related to comparison with CNT and cost acceptability indicated that only 35 percent of the responses judged the polyester/wool fabric as equal to or better than CNT, and only 6 percent of the responses indicated that personnel would pay the $58.00 cost for this uniform.

d) Because of the high cost of the polyester/wool fabric the use of a lighter more air permeable polyester/cotton fabric than used in this evaluation as discussed previously appears to be the only reasonable option for a CNT replacement fabric.

Silicone Crease - Results from laboratory evaluations indicated that the use of a silicone resin in the formation of creases would improve the sharpness and durability of the creases with respect to current methods of forming creases, such as post-curing of durable press resins and heat setting.

RECOMMENDATION

It appears that the most reasonable option for a CNT replacement fabric would be a polyester/cotton fabric having the same weight and air permeability characteristics as the CNT fabric, finished with durable press and soil release resins to maximize appearance and soil removal properties, and the formation of silicone resin creases in garments made from this fabric to further enhance appearance.

Comfort properties should improve from what was achieved in this study with heavier polyester/cotton fabrics and appearance should be similar to that achieved with the polyester/cotton fabrics in this study with more wrinkling during wear than would occur with CNT.

The 6.5 oz/yd^2, 65/35 polyester/cotton fabric used in E-1 summer white trousers would appear to be a suitable choice. It mimics CNT in weight and air permeability characteristics and finished with both a durable press and soil release resins, its appearance and soil removal properties would be improved.

APPENDIX A

NCTRF STAIN-RELEASE RATING SCALE

Editor's Note: Because of the offset process used to print this report, the stains in this figure are not exact reproductions of the stains in the NCTRF rating scale. Therefore, this figure should not be used as a substitute for the official NCTRF Stain-Release Rating Scale.

APPENDIX B

DEPARTMENT OF THE NAVY
Navy Clothing and Textile Research Facility
21 Strathmore Road
Natick, Massachusetts 01760-2490

EVALUATION OF EXPERIMENTAL WHITE DRESS UNIFORM
ENLISTED MEN

The uniforms that you are evaluating were developed by the Navy Clothing and Textile Research Facility. The program is in response to a directive from the Secretary of the Navy for a new Summer Dress White uniform (jumper and trouser) for enlisted men.

The objective of the program is to evaluate the acceptability of Summer White uniforms manufactured from various materials. Your selection and personal opinions/comments on the questionnaire are important in determining which material will be recommended for adoption for the uniform.

You will be issued uniforms(s) identified by a designating number. The uniform(s) are the same design and size measurements as the currently used items. You are requested to wear the uniform(s) as often as possible. At the end of the evaluation you are to accurately fill out the attached questionnaire and include any additional opinions and comments you may have. Upon completion of the questionnaire, return it to your test monitor who will forward it to the Navy Clothing and Textile Research Facility. Your cooperation in assisting in this project is appreciated.

The cleaning instructions on the next page should be followed as closely as possible to assure optimum results.

CLEANING INSTRUCTIONS

Home laundering (applicable to items #1 through #8):

Machine wash WARM, permanent press cycle,
DO NOT USE CHLORINE BLEACH.
Tumble dry, medium heat, remove promptly.
Touch up with warm iron if needed.

Shipboard laundering (applicable to all items):

Follow NAVEDTRA MANUAL 414-01-45-81 FORMULA II.

All items may also be drycleaned.

QUESTIONNAIRE
SUMMER WHITE UNIFORM
ENLISTED MEN

NAME: _____. RATE: _____.

SHIP/ACTIVITY: _____.

UNIFORM #/SIZE
JUMPER: _____. TROUSER: _____.

1. How did uniform(s) fit when issued?

	#1	#2	#3	#4	#5	#6	#7	#8
EXCELLENT:	___	___	___	___	___	___	___	___
GOOD:	___	___	___	___	___	___	___	___
POOR:	___	___	___	___	___	___	___	___.

If poor, where was fit improper? Indicate which uniform(s) by number.

_____.

2. How many times was the uniform(s) worn?

#1	#2	#3	#4	#5	#6	#7	#8
___	___	___	___	___	___	___	___.

3. What method of cleaning was used (A. Home laundry; B. Shipboard; C. Drycleaned; D. Commercial) and number of times cleaned?

	#1	#2	#3	#4	#5	#6	#7	#8
METHOD:	___	___	___	___	___	___	___	___
NO. TIMES:	___	___	___	___	___	___	___	___.

4. Did uniform(s) shrink after cleaning? YES: ____ NO: ____.
If YES, designate which uniform(s) by number and explain where shrinkage occurred.

_____

_____

_____.

5. Did uniform(s) require ironing after cleaning? YES: ____ NO: ____.
If YES, designate which uniform(s) by number and explain where ironing was needed.

_____

_____

_____.

6. Were spots/stains easily removed in cleaning? YES: ____ NO: ____.
If NO, designate which uniform(s) by number and explain type of stains, etc.

_____

_____

_____.

7. How do you rate comfort of the uniform(s)?

	#1	#2	#3	#4	#5	#6	#7	#8
HOT:	____	____	____	____	____	____	____	____
WARM:	____	____	____	____	____	____	____	____
COOL:	____	____	____	____	____	____	____	____
EXCELLENT:	____	____	____	____	____	____	____	____.

If HOT or WARM, please indicate the temperature and humidity relating to these conditions and types of discomfort. Indicate which uniform(s) by number.

_____

_____

_____.

8. How durable was the uniform(s)? (Abrasion, rips/tears, etc.):

	#1	#2	#3	#4	#5	#6	#7	#8
EXCELLENT:	___	___	___	___	___	___	___	___
GOOD:	___	___	___	___	___	___	___	___
POOR:	___	___	___	___	___	___	___	___.

If POOR, please explain. Please indicate uniform(s) by number.

_____

_____

_____.

9. What was overall appearance of uniform(s) after repeated wear/cleaning?

	#1	#2	#3	#4	#5	#6	#7	#8
EXCELLENT:	___	___	___	___	___	___	___	___
GOOD:	___	___	___	___	___	___	___	___
POOR:	___	___	___	___	___	___	___	___.

If POOR, please explain and indicate uniform(s) by number.

_____

_____

_____.

10. How do these uniform(s) compare to current CNT and/or summer white uniforms?

	#1	#2	#3	#4	#5	#6	#7	#8
BETTER:	___	___	___	___	___	___	___	___
SAME:	___	___	___	___	___	___	___	___
WORSE:	___	___	___	___	___	___	___	___.

If WORSE, please explain and indicate which uniform(s) by number.

_____

_____

_____.

11. Which uniform(s) do you prefer? (Select 1st and 2nd choice.)

#1	#2	#3	#4	#5	#6	#7	#8
___	___	___	___	___	___	___	___.

Please list reasons for preference and indicate uniform(s) by number.

_____

_____

_____.

12. Additional comments:

_____

_____

_____

_____

_____.

Signature: _____.

Date: _____.

Appendix C

Rating Criteria for Various Fabric/Uniform Characteristics

1. Strength/Durability

Lab	Rating				
Strength Break (lbs)	1	2	3	4	5
Warp	101-125	126-150	151-175	176-200	201-225
Filling	61-70	71-80	81-90	91-100	101-110
Tear (lbs)					
Warp	1-3	4-6	7-9	10-12	13-15
Filling	1-3	4-6	7-9	10-12	13-15
User					
Durability (%) Good to Excellent	0-20	21-40	41-60	61-80	81-100

2. Air Permeability

	Rating				
($ft^3/min/ft^2$)	1	2	3	4	5
Lab	0-10	11-20	21-30	31-40	41-50

3. Dimensional Stability

	Rating				
(%)	1	2	3	4	5
Lab	4.1-5.0	3.1-4.0	2.1-3.0	1.1-2.0	0-1.0
User	Excessive	High	Moderate	Slight	None

4. Appearance, Laundering

Lab — Rating

Materials and Garments, Non-Pressed

1 - Crumpled, creased and severely wrinkled appearance

2 - Rumpled, obviously wrinkled appearance

3 - Mussed, non-pressed appearance

4 - Smooth finished appearance

5 - Very smooth pressed finished apprearance

4. Appearance, Laundering Lab (cont'd)

	Rating				
Appearance (%)	1	2	3	4	5
Good to Excellent	0-20	21-40	41-60	61-80	81-100

5. Soil Release

	Rating				
Laundering	1	2	3	4	5
Lab	See soil release replica Appendix A				
User					
Easy to clean (%)	0-20	21-40	41-60	61-80	81-100

6. Discoloration

	Rating				
Laundering	1	2	3	4	5
Change in whiteness (%)	41-50	31-40	21-30	11-20	0-10
Change in yellowness(%)	41-50	31-40	21-30	11-20	0-10

7. Shade Change

	Rating				
Laundering	1	2	3	4	5
Lab ΔE	1.7-2.0	1.3-1.6	.9-1.2	.5-.8	0-.4

8. Comfort

	Rating				
User	1	2	3	4	5
Cool (%)	0-20	21-40	41-60	61-80	81-100

9. Comparison to CNT

	Rating				
User					
Same or better(%)	0-20	21-40	41-60	61-80	81-100

10. Preference

	Rating				
	1	2	3	4	5
User (%)	0-20	21-40	41-60	61-80	81-100